Ancient gold mining activity in the Hutti-Muski greenstone belt, Karnataka, India: Radiocarbon perspective

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Present gold-producing centres of India have witnessed ancient and modern mining activities. The presence of wood logs, ash, charcoal and pottery in ancient gold mines of Kolar, Hutti and Uti suggests fire setting was the main mode of gold exploitation of ancient miners. In the absence of historical records pertaining to the episodes of ancient mining activity in Karnataka, wood material found in the ancient gold workings were used to constrain the episodes of mining activity. We have radiocarbon (^{14}C) dated a wood log from the Uti gold mines, which reveals that the ancient mining activity here dates back to AD 660–780. This date from Uti mine together with the earlier published ^{14}C dates from Kolar fields imply that the ancient gold mining activity was contemporaneous at these places, while the Hutti fields were exploited during the early part of the Christian era.

Keywords: Ancient gold mining, Christian era, Kolar, radiocarbon, Uti gold mine.

INDIA'S major gold producer is M/s Hutti Gold Mines Co. Ltd. (HGML), Karnataka, who owns three gold mines (Hutti, Uti and Hira-Buddinni) with a combined production of about 2846 kg gold during 2005–06. The antiquity of gold mines in Karnataka is quite old[1] and the ancient gold mines are still acting as beacons for modern-day gold mines. Majority of old workings were brought to light by Foote[2] during his geological traverses in Karnataka[3]. Over 300 ancient workings were identified in the Hutti–Muski schist belt, Karnataka[4]. The deepest mine depth happens to be 200 m from ground level at Hutti. Some of the ancient workings were considered to be 3000 years old[5].

Another auriferous tract in Hutti-Muski greenstone belt, known as Uti gold mine area, is in the Raichur District, Karnataka. The Uti gold mine is located about 22 km northeast of the Hutti gold mine (Figure 1 *a*). The geological set-up of the Uti gold deposit was described by Biswas[6] and Sangurmath[7]. The main litho-units are amphibolite, acid volcanics, carbonaceous schist, pegmatite, basic dykes, quartz veins and the gold-bearing zones. The Geological Survey of India (GSI), HGML and Min-

eral Exploration Corporation Ltd. (MECL) have carried out gold exploration activities in the Uti auriferous deposits[8], based on which the detailed opencast mining of gold was embarked on, at Uti.

Evidence of ancient mining activity was observed during the course of opencast mining in Uti gold mines[8]. It was
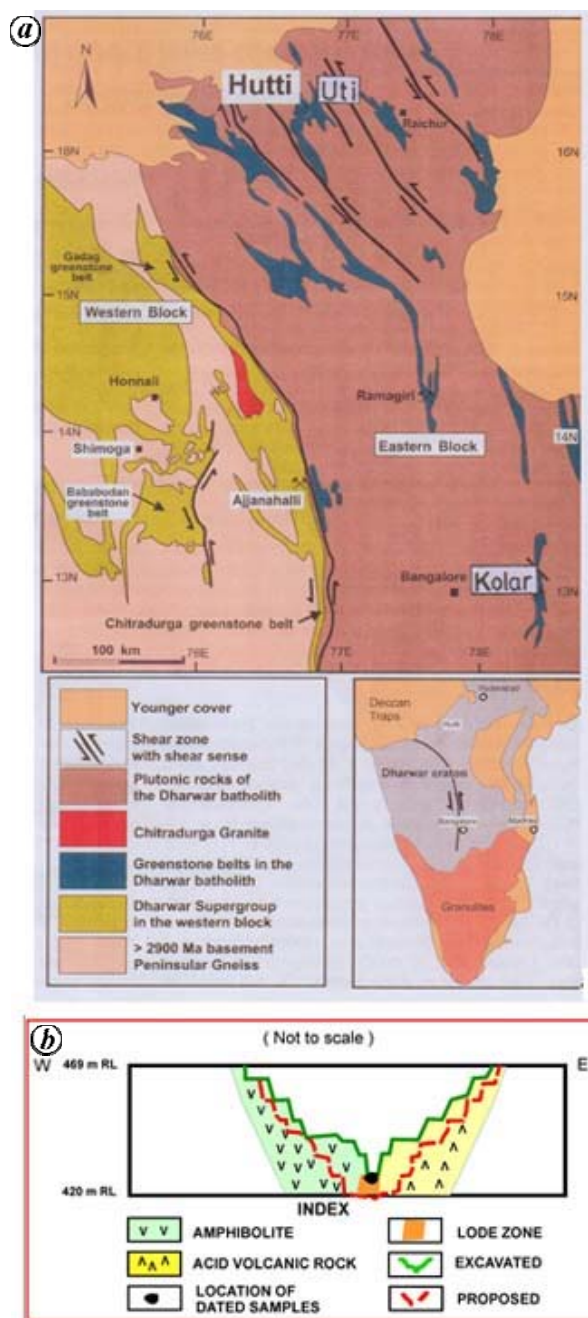

Figure 1. *a*, Schematic geological map of the Dharwar craton and its location in southern India (adapted from Jochen *et al.*[16]). Locations of Kolar, Hutti and Uti gold mines are shown. *b*, Geological cross-section of Uti mine depicting various formations and the location of dated wood log.

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Table 1. [14]C dates from Uti, Kolar and Hutti gold mines

Site	Sample no.	Locus	[14]C age (yr BP)	Calibrated date[15]
Uti	N-928	~40 m below reference level (Figure 1 b)	1290 ± 60	660 AD–780 AD
Kolar*	TF-1199	Superficial excavations	1290 ± 90	660 AD–860 AD
Kolar*	TF-879	Champion reef 50 m depth	1500 ± 115	430 AD–660 AD
Hutti*	Sample no. 1	Oakley's shaft 80 m depth	1945 ± 70	40 BC–130 AD
Hutti*	Sample no. 2	Oakley's shaft 80 m depth	1865 ± 70	70 AD–240 AD

*Agrawal and Margabandhu[13].

Figure 2. Wood log obtained from the Uti ancient gold mine.

observed that these old workings were stretching up to a depth of 20–25 m, and contained wood, charcoal, ash, pottery, etc. The geological cross-section of the open-pit (Figure 1 b) shows presence of amphibolites in its western face, acid volcanic rocks in its eastern section, and the lode zone. Mineralization in the mafic rocks is mainly confined to intensely silicified and feldspathized amphibolite with thin stringers, veins and veinlets of quartz, associated with the sulphides (pyrite, arsenopyrite, pyrrhotite, etc.). Mineralization is notable with a uniform impregnation of silica in the ore zone. A wood log was collected from the mineralized zone. On the basis of presence of wood, charcoal, ash, pottery, etc. in the old workings, it was interpreted that ancient miners extracted the ore through fire-setting process followed by water-cooling of the heated rock. This was evident from the presence of visible gold over the surface of charcoal coated burnt quartz in the open pit old workings[8].

Forbes[9] observed that in ancient times the main supply of gold was from Egyptian deserts of Nubia. The Egyptians were known to have mined gold in Nubian sands 6000 years ago, and continued for many centuries[10]. It appears that the Rhodesians were inspired by the ancient mining activity of Karnataka, and developed their mining activity since 3rd century[11]. Mining of ores in Karnataka spans as back as centuries preceding and immediately following the Christian era[5]. With a view to unraveling the epochs of ancient workings in Ingaldhal copper ore mines, Shankar[12] carried out the ^{14}C dating of wood logs obtained from the old workings of Ingaldhal copper mines of Karnataka, and concluded that the ancient mining activity belonged to the Satavahana period (2nd century

BC to 2nd century AD). Similar studies[13] in the ancient gold workings of Kolar gold mines revealed existence of mining activity during 5th to 7th century AD, while in Hutti gold mines the epoch of ancient gold exploitation activity was much earlier (pertained to the beginning of Christian era; Table 1). It appears that due to overlap of ^{14}C dates (1290 ± 90 and 1500 ± 115 yr BP; Table 1) from Kolar mines, Agrawal and Margabandhu[13] opined that the gold fields were exploited from 5th century AD.

In the present study, the timing of ancient gold exploitation in the Uti gold mines was constrained through radiocarbon dating of wood log (Figure 2) recovered from the mine by one of the authors (PS). The wood log was subjected to preprocessing procedure and combustion of wood for extraction of carbon dioxide (CO_2), synthesis of acetylene and benzene from the extracted CO_2, and residual radiocarbon activity determination using low level liquid scintillation counter[14]. The wood sample was partitioned into three parts, each part separately combusted for extraction of CO_2, synthesized acetylene and benzene and determined ^{14}C date. Average date was computed from the three independent dates. For radiocarbon age calculation of the wood log, 5730 yr half-life and $\delta^{13}C$ of –25‰ were used. The dated wood showed an age of 1290 ± 60 yr BP. The calibrated[15] date of the wood is 660–780 AD (1σ error). It is interesting to note that the present radiocarbon date (1290 ± 60 yr BP) of the wood log from the Uti ancient gold working and the date (1290 ± 90 yr BP) reported by Agrawal and Margabandhu[13] for the Kolar gold field ancient workings together reveal contemporaneous mining activity at both the gold fields.

We conclude from the ^{14}C date of wood log obtained from Uti ancient gold mine and from the published ^{14}C dates pertaining to the ancient mining activities at Hutti and Kolar gold fields, that the gold exploitation was either contemporaneous around 7th century AD at Uti and Kolar auriferous tracts or it followed after probable (?) cessation of mining activity at Hutti fields, which were exploited during the early part of the Christian era. The present finding and that of Agrawal and Margabandhu[13] raise two issues to be addressed. One issue pertains to the continuation of gold mining activity in the Deccan between 5th and 7th century AD in contrast to the observation by Curtis and Radhakrishna[5] that the gold mining activity in the Deccan ceased completely between 5th and 6th century AD.

The second issue concerns the 1200-year long period dormancy of gold mining activity after 6th century AD[5]. Answers to these issues, perhaps, lay in the episodes of other ancient gold mining activities in the Deccan, which needs to be unraveled.

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Analysis and mapping of soil quality in Khandaleru catchment area using remote sensing and GIS

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The problem of soil quality in and around reservoirs is attracting attention for the last couple of years due to the unscientific and unplanned irrigation practices that are bringing a myriad problems. Modern agricultural practices such as pumping of groundwater for irrigation and indiscriminate use of fertilizers containing toxic substances contribute to environmental degradation. Such anthropogenic activities invariably result in the depletion of water bodies, deterioration of soil quality, contamination of drinking water and various health hazards. Hence there is need to study in a comprehensive manner about the soil quality issues in the catchment areas. The present study is an attempt to analyse the physico-chemical parameters and generate the soil quality index (SQI) in and around Khandaleru catchment, Nellore District, Andhra Pradesh. The soil samples collected at the predetermined locations were analysed for physico-chemical parameters for the generation of attribute database. Based on the results of the analysis, spatial distribution maps of selected soil quality parameters, namely bulk density, moisture content, organic matter, C%, pH, electrical conductivity, Ca, Mg, SO$_4$, nitrate, phosphorus, potassium and texture were prepared using curve-fitting method in GIS software. The physico-chemical analysis properties and computation of SQI are helpful in the grouping of soil samples into excellent, good, poor, very poor and unfit. The spatial distribution of SQI generated in the current study will be of use for planners in the management and monitoring of land resources.

Keywords: Physico-chemical parameters, remote sensing and GIS, soil quality index, spatial distribution.

SOIL is a living system that represents a finite resource vital to life on earth. It forms a thin skin of unconsolidated minerals and organic matter on the earth's surface. It develops slowly from various parent materials and is modified by time, climate, macro- and microorganisms, vegetation and topography. Soils are complex mixtures of minerals, organic compounds and living organisms that interact continuously in response to natural and imposed biological, chemical and physical forces. People are dependent on the soil, and conversely, good soils are dependent on people and the use they make of the land. Soils are the natural bodies in which plants grow. The soils

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