SIMLIPAL IMPACT STRUCTURE- ITS REMOTE SENSING IMAGES AND POSSIBLE IMPORTANCE IN EVOLUTION OF EARLY-MIDDLE ARCHAEAN SINGHBHUM-ORISSA CRATON, EASTERN INDIA.

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Introduction: The Simlipal structure (centered at 21º 52/ 24//N, 86º 20/ 14//E) is a semi-circular basin with an average diameter of c. 45 km, located in the southeastern part of the Palaeo- to Mesoarchaean Archaean Singhbhum-Orissa Craton (SOC), eastern India [1]. Although, this structure occupies ~17% of the total areal extent of the SOC, importance of this basin in the evolution of the craton was never discussed before. The basin was described initially as a volcano-sedimentary succession [2], however, recent study favors for an asteroid impact origin for this structure [3]. Here, we present the results of our preliminary observation on the Landsat satellite imageries of the Simlipal structure, and discuss the possible effects of this impact on the geological evolution of SOC.

Regional geology: The ovoid SOC nucleus, encompassing an areal extent of $40x10^3$ sq. km., comprises of enclave supracrustals and intrusive voluminous granitoids that evolved between ~4.24 and 3.28 Ga [4, 5]. According to Saha [1], this granitoid basement is overlain to its north and east by a deformed and metamorphosed supracrustal sequence, known as the Singhbhum Group, which likely evolved between ~3.28 and 3.09 Ga along the boundary of the SOC basement [5, 6, 7]. The Simlipal basin is excavated within the Singhbhum Group, intruded along its flank by 3.09 Ga old A-type Mayurbhanj Granite, and associated gabbro-anorthosite rocks [1, 6, 7]. This basin, with an areal extent of ~7 x 10^3 sq. km. [1], is occupied by mafic volcanics with a basal arkosic-orthoquartzite horizon, and two other thick inter-trappean orthoquartzite horizons; the central part of the basin is occupied by a ~800 m thick differentiated ultramafic-mafic intrusion known as the Amjori Sill that varies from bottom to top from dunite, peridotite, picrite, gabbro to quartz diorite [2].

Remote sensing images: A Landsat 8 imagery of the Simlipal basin, acquired on April 10, 2013 [8] with P/R 139/45 and band combinations 7, 4, 2, is shown in Figure 1. The image shows that it is an elliptical structure with a NE-SW symmetry plane. The structure is surrounded by a raised outer rim (1) with an average elevation of 700 m. This outer rim is currently best preserved to the south and southeast (Fig. 2). Inside the basin, there is another prominent semi-circular rim (2) that has an average height of ~850 m. It is clearly recognised in Figure 1 that the basin is intersected by late WNW-ESE (ab) and NNE-SSW (cd) orthogonal cross-cutting fractures, which are best developed along the southern sector of the Simlipal basin as demarcated by fracture 'ef' and a blue box, respectively. The outer rim of the basin to the south is found to have displaced along a NNE-SSW dextral fault. However, the effect of any faulting on the outer rim of the structure to the north is hardly recognised in the current satellite imagery.

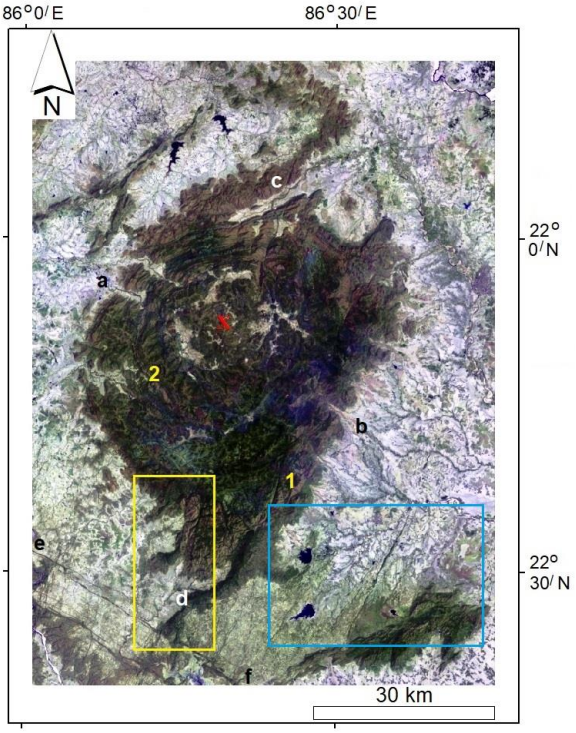

Fig. 1. Landsat 8 image of the Simlipal basin (coloured part) and its surroundings; 1- outer ring, 2- inner ring, ab- WNW-ESE fracture, cd- NNE-SSW fracture, ef- prominent set of WNW-ESE fracture, yellow box- showing dextral faulting of the outer rim of the basin along NNE-SSW fracture, blue box- showing well developed NNE-SSW fracture.

The DEM imagery prepared for the Simlipal structure with 100 m contour interval shows a substantial variation of DEM from 600 m of outmost structure to a maximum of ~ 1100 m in inner part. The average elevation of the structure is ~ 800 m, and it is slightly elevated towards S and SW.

Discussion: Master et al. [3] currently identified the Simlipal basin as an erosional remnant of an aster-

oid impact structure. Their preliminary observation on the occurrence of shatter cones developed on the basaltic rocks at Uski Falls, close to the geographic center of the basin, was the main foundation of the hypothesis. Based on gravity profile [9], they further suggested that the central part of the basin was occupied by a 3 km thick undeformed, horizontally bedded differentiated impact-melt sheet, similar to the differentiated melt-sheet in the Sudbury structure [10].

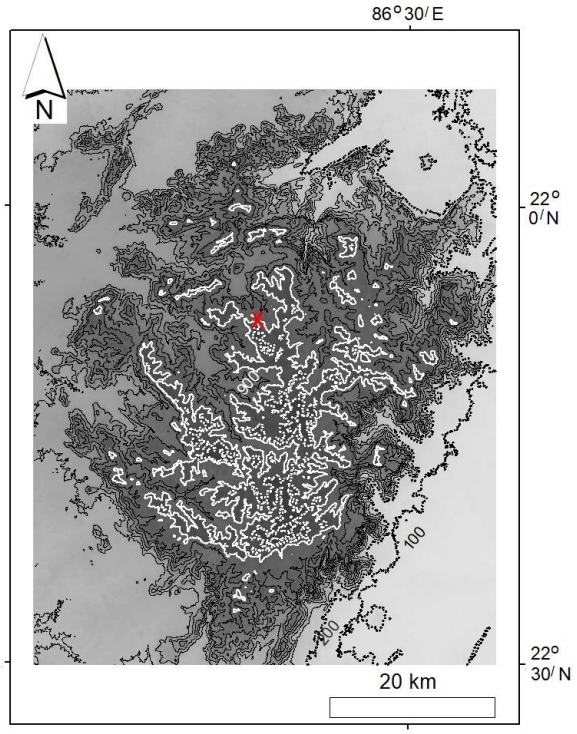

Fig. 2. Topographic map of the Simlipal basin prepared from SRTM-DEM with a contour interval of 100 m, white contours represents 900-1100 m, black contours represents 500-900m, dash contour is of 200m.

Intrusive relationship of the A-type Mayurbhanj Granite and time-equivalent gabbro-anorthosite body along the flank of the basin constrains the minimum age of impact before 3.09 Ga [1, 6]. If we assume the configuration of the Gondwanaland as reference, the Indian sub-continent was sandwiched between the Antarctica and Madagascar/ Africa, and geographically closer to the Palaeo- to Mesoarchaean Kaapvaal Craton, southern Africa before 200 Ma [11]. The recently reported Archaean impact ejecta units in the Kaapvaal Craton, Southern Africa, and the Pilbara Craton, western Australia were interpreted to represent the possible event of global asteroid bombardment between ~3.25 and 3.22 Ga that resulted in faulting, large scale uplift, intrusions of mafic–ultramafic and granitoid plutons, to semi-continental conditions represented by arenites, turbidites, conglomerate, banded iron formation and felsic volcanics [12]. Hence, pre-3.09 Ga old Simlipal impact structure perhaps represents the tail end of the ~3.25-3.22 Ga global asteroid bombardment event or might coincide with the extended period of post-accretionary bombardment.

The elliptical shape of the Simlipal structure is consistent with an oblique impact [13]. As Indian subcontinent rotated ~ 65° anti-clock wise after the Gondwana breakup to attain its present position [14], the paleogeographic reconstruction suggests that the original plane of Simlipal impact was likely sub-parallel to the E-W planet's equatorial plane or oriented along ESE-WNW plane.

The identification of the eroded Simlipal basin, originally encompassing an area > 7 x 10^3 sq. km., as a mega-impact structure has a great significance in understanding the Mesoarchaean crustal growth of the SOC. The Simlipal basin is spatially and temporarily associated with the Singhbhum shear zone, showing the oldest record of movement at ~3.09 Ga, and A-type bimodal Mayurbhanj Granite pluton of same age [6]. It appears that the Singhbhum shear zone, once considered as a subduction zone [1], could be a prominent radial fracture developed due to this impact. The origin of the bimodal Mayurbhanj Granite could be related to impact, and arguably similar to those of the A-type White Mofolozi Granite pluton in SE Kaapvaal Craton [15] or the Bushveld igneous Complex [16]. Thus, Simlipal structure possibly represents one of the preserved, unexplored early impact records on the Earth.

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