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Sunaparanta Revisited: Political Ecology and Economy of Gold deposits in Goa

Dr. Nandkumar M. Kamat, Asst. Professor, Dept. Of Botany, Goa University

Prelude

This paper mostly based on my previously published articles and new research is about the science and politics of Gold deposits in Goa- a fact known to ancient Goans, Buddhist monks, travellers and mineral prospectors but denied by the state government, hidden by the central government and ignored by the Shah commission. Gold is in high demand. India is still importing Gold worth $ 10 -15 billions annually. International and domestic prices are rising. Americans want their gold standard back. Gold, a chemical element with the symbol Au, is a highly sought-after precious metal, having been used as money, in jewellery, in sculpture, and for ornamentation since the beginning of recorded history. Gold is the best known of all native elements and the most likely to be found in a metallic state. Gold is almost everywhere considered to be the symbol of everything precious and of enduring value because of the effort required to extract it from nature, and because of its scarcity relative to other metals. Gold was known and highly valued by the earliest civilizations: Egyptian, Minoan, Assyrian, and Etruscan.

The unique combination of chemical and physical properties makes it invaluable in numerous of everyday appliances and applications and jewellery. The metal forms a vital component of many medical, industrial and electrical applications. Gold alloys are used for electroplating, granulation, pressing, and lamination. High reflectivity (99 %) of gold makes it ideal for Infrared heaters, cookers, as shielding for spacecrafts and satellites and in life saving face shields for astronauts and fire fighters. Gold is used in spot plating, strip plating, and reduction in thickness of plated surface, ayurvedic preparations, and treatment of prostate cancer, arthritis, medical diagnosis, radio therapy and medical research. Gold has been made into thread and used in embroidery of clothes. Gold plated palladium, tin and nickel are used in electronics. Titanium and chrome alloys are used in dentistry. High prices of gold promote the use of base metal-clad gold in electronics, electrical and jewellery products. Gold performs critical functions in computers, communication equipment, spacecraft, jet aircraft engines, and a host of other products.

Economic and cultural history of Gold in Goa:

Gold craftsmanship in Goa could be as old as Indus civilization.The design of necklaces, bangles, ear rings, broaches found in Mohenjo-daro and Harappa show remarkable typological similarity with some of the designs of Goa's Gold artisans. Gold chemistry and metallurgy in Goa thus dates back to Indus civilization period. But what was the supply of Gold in Goa?. During the Buddhist and later Mauryan period the Konkan region between Thana to Karwar was known as "land of Gold" or Sunaparanta. The Buddhist text Punnovada sukta –Gautam Buddha's preaching to Punna from Supparaka or Sopara near modern Thane, 400 kms. from Goa has an interesting dialogue- after preaching Buddha asks Punna, "Now that I have given you this brief advice, Punna, In which country will you dwell?" "Venerable sir, now that the Blessed One has given me this brief advice, I am going to dwell in the Sunaparanta country." Why this region was called 'land of Gold"?. Obviously, it was

producing it plentifully-most probably it was alluvial placer Gold found in rivers flowing from the western ghats. The chronicler of Indus-Saraswati civilization, Dr. Kalyanraman has documented the rich traditions of Gold craftsmanship of the Indus culture. This influence diffused to the west coast in Sunaparanta. The Kadambas of Goa are known in Indian numismatics for some of the finest Gold coins –the padmatankas which were deeply punch marked. Relatively very few of their copper coins have been appreciated. A surplus supply of Gold compared to copper or silver made the Gold coinage of Kadambas possible. The most interesting account of Gold coin minting industry has been given by historian Dr. Pissurlenkar while mentioning archaeology of Cudnem village in Bicholim taluka. In area known as Gujirpeth people used to find Gold coins loosened from soil after the monsoon. A 12 th century AD golden ear ring displayed in the museum of society of Pilar shows the level of local Gold craftsmanship of that period. Gold artisanship demands a lot of knowledge about the chemistry of Gold and its' alloys. The supply of Gold must be the local primary or secondary alluvial Gold. There is a high possibility of Gold associated with eroded laterite and found with exposed bauxite and saprolite. People would not have missed the shining metal grains or exposed particles. In Nilambur , Kerala, Gold has been found in laterite. Normally toponymy in India shows that place names or village names would indicate any association with Gold deposits, Gold craftsmanship or trade in Gold. Hills like Sonsagar (ocean of Gold) in Goa's western ghats might have been prospected for Gold deposits. Sonshi, Sonus are some of the place names which fall within present iron ore mining belt. Zambaulim is probably derived from Zambhava or Gold. Similarly an interesting village name in Sanguem taluka, on south central railway route is Sonaulim-indicating perhaps location of gold deposits which were once found there.

Gold in biosphere:

Gold occurs as nuggets or grains in rocks, in veins and in alluvial deposits. As Gold is widely distributed in biosphere the various organisms has the ability to accumulate Gold (Korobushkina et al., 1983; Reith 2003). Macro fungi are one of the well known accumulators of micronutrients such as Copper, Zinc, Maganese and trace elements which includes heavy metals Cadmium, Mercury; metalloids Selenium, Arsenic; radionuclides 137Caesium and also noble metals like Silver, Gold (Borovicka et al., 2006). The geochemical cycle of Gold is complex as it gets dissolved and sometimes reprecipitated in the weathering profiles (Colin and Vieillard, 1991; Mann, 1984; Proto and Hale, 1996; Bowell et al., 1993 a; Freyssinet et al., 1989 a, 1997). Since micro- organisms play important roles in solubilising metals and also in mineral deposition in the natural environment hence these processes are exploited for recovery of metals and also decontamination of metal polluted areas.

Geomicrobiology and Geochemistry of Gold:

Rocks forming the upper lithosphere in biosphere contain minor quantities of Gold. Soil contains Gold in form of organo-mineral complexes. The marine bodies contain Gold in very small quantities which can vary through the range of 0.003 to at least 44 mg. per cubic meter (Putnam 1953; Savvaidis et al., 1998). Table 1 gives the natural occurrence of Gold. Thus presence of high Gold content in biosphere than water bodies indicates that it is involved in cycling processes. Biosphere catalyses different biogeochemical processes and transforms Gold. Microbial weathering is an important phenomenon which helps in mobilization of elemental Gold by releasing Au trapped in mineral rocks and gets it into solubilising form. Secondary Gold formation occurs by subsequent microbial destabilization of Gold complexes coupled to bio-precipitation and biomineralization. Secondary Gold can occur as crystalline Gold,

nanoparticles and bacteriomorphic structures, the latter being a controversial form of `biogenic' Gold (Reith et al., 2007; Southam et al., 2009). Annexure given at end of this article gives excerpts from a local magazine cover story on my pioneer discovery of such microbiogenic Gold forms in Goa.

Table 1 Natural occurrence of Gold

Rocks, soils, waters	Au content (mg.103 kg-1)	Reference
Igneous rocks (acidic, basic, intermediate, ultrabasic)	< 50	Zvyagintzev (1941), Vinogradov (1962), Degracia and Haskin (1964), Phan (1965), Shcherbakov (1967)
Sedimentary rocks (sandstone, lime, shale, slit etc)	<200	Zvyagintzev (1941), Vinogradov (1962), Degracia and Haskin (1964), Phan (1965), Shcherbakov (1967), Razin and Rozhkov (1966), Chebotarev (1969)
Coal	< 1,000	Zvyagintzev (1941)
Soils	< 2, 000	Vinogradov (1957), Razin and Rozhkov (1966), Lezhneva (1978)
Earth's crust	Approx. 4.3	Vinogradov (1962)
Waters of rivers Waters of auriferous deposits	.10-3 mg l-1 0-3.10-2 mg l-1 < 1.0 mg l-1	Kropachev (1935), Razin and Rozhkov (1966), Progrebnyak et al., (1980)
Marine water	< 5.0 . 10-2	Kropachev (1935)

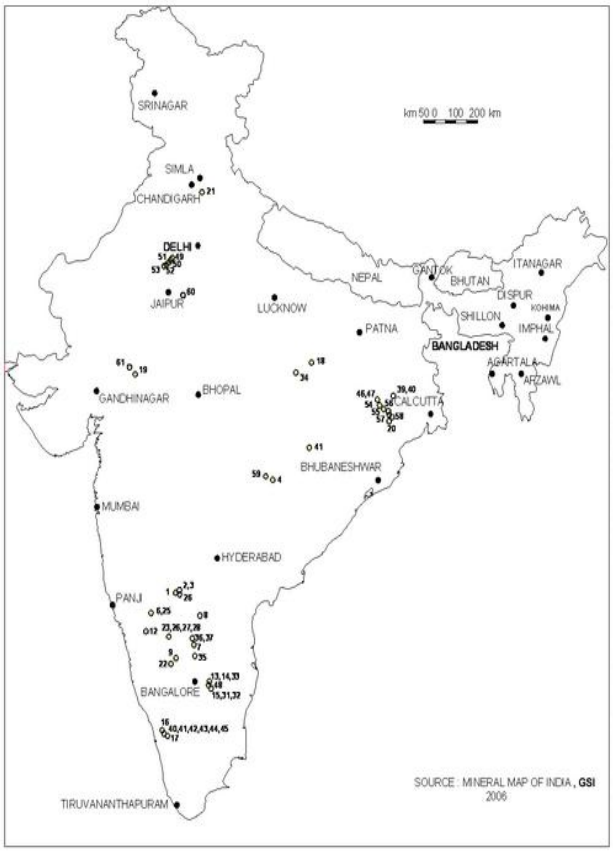
(Source:- Korobushkina et al., 1983)

Gold deposits in India

India is known as the land of Gold since ancient times. Evidence of ancient Gold mining activity is spread over length and breadth of the country. Many Gold mines were opened up in South India namely Kolar, Hutti, Gadag, Ramagiri and Honalli etc. Currently Gold is produced mainly from three mines in Karnataka (Hutti, Uti and Hirabuddini) and one in Jharkhand (Kundrekocha). Production of Gold bullion in India is reported both from primary and secondary sources, the latter includes

recovery from imported copper concentrates. Gold is a scarce commodity in India but the country has a traditional market and stable pattern of Gold consumption. Historical production and presence of world class Gold deposits in the country suggests that India has potential geological domain for search of Gold.

Gold evolves as a siderophile element from the Iron - Nickel core at crustal spreading centers. During partial melting of the mantle, gold along with metals derived from sulphides rise with basaltic (magmatic) fluids into the crust along mid-oceanic ridges and at subduction zones. It is then associated with complex processes involving convection, subduction, partial melting, hydrothermal processing, weathering, erosion and deposition before being returned to the mantle for recycling again at subduction centers. The deep seated ore bearing solutions containing gold are of both magmatic and metamorphic origin. The temperature, pressure, pH, salinity, redox, and sulphur content hydrothermal fluids influence the metal carrying capacity. Geochronological data of gold metallogeny revealed major periods of enrichment as Archaean and Proterozoic. Gold occurs in a variety of litho assemblages, and multiple geological environments / settings such as greenstone belts, mantle derived intrusions, diaperic juvenile plutons and granulites. In the Indian subcontinent, prominent granite greenstone belts of Peninsular Sheild are located in Dharwar, Bastar, Singhbhum and Rajasthan cratons. The Dharwar craton, with two blocks viz the eastern and western, hosts the maximum number of gold occurrences. The Eastern block provides an important and favourable lithologic, structural and stratigraphic milieu for gold mineralization and hosts major deposits like Kolar and Hutti. In the northwestern Indian Shield, gold occurs in association with copper in the Archaean greenstone-like sequence (at Dhani Basri, in Mangalwar Complex) and Proterozoic metavolcanosediments (at Bhukia and Dugocha, in Aravalli Supergroup) with enrichment in the latter. Gold also occurs in Palaeo / recent river alluvium placers, laterite, soil and regolith. Puga geothermal system is a “hot spring type epithermal gold deposit in the making, in the Ladakh region of Jammu and Kashmir. The distribution of gold occurrences in India is shown in following figure (fig. 1)



GOLD AND ASSOCIATED METAL PROSPECTS IN INDIA

1. Hutti Gold mine, Au, W
2. Uti block, Au, W
3. Wandalli-Hira-Bundhini-Chinchergi, Au, W
4. Sonadihi, Au
5. Hossur Champion block, Au, W
6. Mysore Sangli mine, Au, W
7. Ramagiri-Kotapalle Gold Field, Au
8. Dona tample, Au
9. Ajjanahalli, Au
10. G.R.Halli, Au
11. Kampinokote, Au
12. Chinmulgund, Au
13. Kolar Gold Field, Au, W
14. Old Bisanattam mine, Au,W
15. Mallaapakonda, Au, W
16. Nilambur valley, Au
17. Attapadi Valley, Au
18. Gurhar Pahar, Au
19. Anandpuri-Bhukia, Au
20. Kunderkocha, Au
21. Mubarakpur-Una area, Au
22. Bellara, Au
23. C.K. Halli, Au
24. Attikatti block, Au
25. Kabuliyatkatti block, Au
26. Chinchergi, Au
27. Hira Budini, Au
28. Kadoni, Au
29. Sanbal, Au
30. Tuppadhur, Au
31. Chigarkunta block, Au
32. Maharajagadai, Au
33. Surapalle prospect, Au
34. Gullaldih, Au
35. Penukonda prospecat, Au
36. Bhadrampalle, Au
37. Ramapuram, Au
38. Honnali, Au
39. Lawa, Au
40. Myscra, Au
41. Sonakhan, Au
42. Phoenix mine, Au
43. Solomine mine, Au
44. Alpha mine, Au
45. Harewood mine, Au
46. Pahardiha, Au
47. Imaliya, Au
48. Kudithainapalle, Au
49. Singhana-muradpur-pancheri, Cu,Au
50. Madhan-kudan, Cu,Co,Au
51. Akwali-kolihan,Cu,Au
52. Chinchroli-surahara-dholamala,Cu,Au
53. Satkui Cu,Au
54. Turamdih,Cu,Au
55 Tamapahar,Cu,Au
56. Rakha,Cu,Ni,Co,Au
57. Surda-mosabani,Cu,Au
58. Baharagora, Cu,Au
59. Pular-parsori-ranmangli-thutanbori,Cu,Au
60. Dhani Basri, Cu,Au
61. Dugocha,Au

Romans were probably the first to organize gold mining and exploration in a systematic fashion. The evidence of large scale fabrication of gold art objects and jewellery were discovered by archaeologists dating back to about 3000 BC in Sumerian tombs at Ur in Mesopotamia. Gold was smelted in Egypt and Sumeria about 3500 BC. In India, references to gold are found in the Rig Veda, the Puranas, Mahabharata and Ramayana and other epics but there is no record of ancient mining places and periods. It finds mention by different names in our scriptures since ages. Gold was mined in India 1800 years before the present or 200 A.D. as proved by Carbon-14 dating of timber recovered from Hutti Gold Mines. Evidence of gold mining activity is spread over length and breadth of India, but obscured due to lack of preservation of data, leading to discovery and rediscovery at many places. Presence of old workings, mine dumps, panning sites, muck heaps, earthen retorts, slag and ore grinding - pounding implements along auriferous tracts in India are commonly observed. Ancient gold mining was carried in two distinct periods, of which earliest one commenced at an unknown date and continued up to about 500 - 600 A.D. while the second episode of intensive and extensive exploration and mining resumed after a gap of over 1000 years, which led to discovery of Kolar and Hutti gold filelds (1870 A.D). Kolar, the second deepest (3200 m) gold mine in the world, survived for 110 years and the Hutti gold field witnessed four periods of widely separated exploration and mining Viz, Pre Asokan +2000 years old, Nizam period 1886 - 1920; 1937 to 1947; and the present and most successful from 1947 onwards. The deepest known old working in the world of about 250m in length and over 195m in depth is located on the Main reef at Hutti gold mines.

The advent of worldwide gold rushes in 19th century laid the foundation for present day mining activity. The gold boom was experienced in India with discovery and mining in Kolar, Hutti, Gadag, Ramagiri, Honalli, Wynad, in the South and a few in

North viz, Lawa, Mysara, Pahardia, Kundrekocha, etc. Most of the old workings were closed due to dwindling production and prevailing cost-benefits.
The extraction of gold involves ore crushing, concentration, slurrying, scrubbing, desliming, gravity processing, leaching (chemical, bacterial, carbon-in pulp and carbon in leach), floatation, ion-exchange, fluxing, amalgamation, cynadation, roasting, and smelting. Selection of metal extraction method or combination depends on nature occurrence of gold, fineness, grain size, rock type, time taken, accuracy, precision, economics, efficiency, hazards and ecological / environmental factors. The Carbon-in Pulp (CIP) leaching process is used to treat low grade oxidized ores at Ajjanahalli.

Spatial and temporal distribution of Gold:

Although primary and secondary Gold are known from the vast tract of Peninsular and Extra Peninsular India, the major primary occurrences are restricted to Peninsular shield. All the three deposit types namely, primary, placer and lateritic types are recognized but the placer and lateritic types have not yet proved to be economic. The important primary Gold provinces where geological environment is suitable for Gold mineralization are:-
i) Archaean granite greenstone terrain of Dharwar, Bastar and Singhbhum craton.
ii) Proterozoic volcano-sedimentary Fold Belts/Supracrustal belts of Eastern, Western and Central India.
iii) Proterozoic volcanogenic polymetallic sulphide deposits of Western India.
iv) Granulite terrain lying in Kerala and Tamil Nadu.
v) Archaean/Proterozoic quartz-pebble conglomerate (palaeo placer type).

Lateritic Gold occurs as capping in the southern granulite terrain and also in the Archaean/Proterozoic volcano-sedimentary belts of South, East and Central India. Secondary placer (alluvial) Gold in small quantity occurs widely in different parts of the country along the river courses draining the rocks of Peninsular India and the Himalayan belt, particularly the Siwaliks.In the Himalayas, minor association of Gold is known along with basemetal sulphides.
Global Gold metallogeny has recognized that the Archaean period between 2800 and 2600 Ma was the most favourable for concentration of Gold as vast Gold deposits were formed during this period in the greenstone belts within cratonic areas. Gold mineralization again reached a high during the last 100 million years of the earth's history. Limited geochronological data reveal that Gold mineralization in India was episodic, with major period of enrichment in the Late-Archaean (2800 – 2500 Ma) and a few in the Mid-Archaean (> 3000 Ma). Another period is the palaeo-Proterozoic where the Gold prospects within the Fold Belts/Supracrustal Belts of Central, Western and Eastern India are mostly with or without basemetals. Presence of Gold is known with Malanjkhand Copper deposit. Except for sporadic occurrences, Gold deposits are absent in Post Proterozoic younger rocks developed in Indian subcontinent.
The Dharwar craton records maximum number of Gold occurrences in the Archaean granite greenstone terrain, hosting all the major Indian Gold deposits in the greenstone belts. Gold has been recorded from adjoining granitoid also. A major north-south trending shear zone divides the craton into eastern and western blocks. The eastern block is more potential, hosting all the major deposits. Gold deposits, though less in numbers, are found in western block also (Information obtained from

abstract vol of May 2009 organised by geological survey of India Banglore and the Hutti gold mine company limited).

Gold in laterite in India

Laterite is a product of intense sub aerial weathering; it hosts numerous valuable economic deposits like Nickel, Manganese, Iron, Alumina, Gold etc. Gold occurrence, in laterite due to economic importance is gaining significant attention in recent year especially after the discovery of workable deposits in Boddington, Yilgarn, Australia. In India, Wynad-Nilambur Gold fields of Tamil Nadu and Kerala were the earliest to be explored. Field observations show that Gold occurrence in laterites and in the weathered zones as thin films confined to cracks of the iron stained quartz and occasionally in clay and limonite zones as visible specks. Quartz veins are the host units for Gold mineralization which can be classified as

Massive milky white veins and Small veins with ferruginous material or cavities typical of sulphide leaching. The Gold particles from weathered zones show various morphological features as depicted by SEM photographs. These can be grouped into 3 types viz

(1) Primary Gold associated with quartz veins in bed rock association with sulphide/quartz mineralisation,

(2) Gold in the weathering zones, depicting the progressive changes such as corrosion, rounding of faces, disappearance of primary shapes and neoformed crystals and

(3) Completely recrystallized grains in the laterite zones. Compositional analysis of the Gold grains from different zones of insitu profiles have been carried out to trace the path from lode to successive residual deposits.

Gold shows significant fineness variation associated in different zones of insitu laterite profile. Fineness varies from 664 - 685 ppm in quartz veins associated with bed rock, in weathered zone it is 890 - 940 ppm and in laterite zone the variation is 970 – 1000 ppm. Variation in the composition / fineness reflects the dissolution of primary Gold and precipitation as supergene Gold. Morphological evolution of Gold grains supports this observation. The dissolution and reprecipitation of Gold during lateritisation further reflects the loss of silver with increase in fineness of Gold associated with bed rock to laterite zones. Geochemical data from different units of the insitu laterite profiles suggest a two stage process in the formation of the laterite. The first stage is marked by rapid depletion of Silica, Lime, Magnesia and alkalies with enrichment of Fe_2O_3, Al_2O_3, and TiO_2. In the second stage there is gradual depletion of SiO_2, CaO, MgO, Na_2O, and K_2O with corresponding enrichment of Fe_2O_3, Al_2O_3 and TiO_2. Trace elements Chromium, Copper, Nickel, Cobalt, Vandium and lead also show enrichment from bed rock to laterite. Gold also show a consistent upward enrichment with highest concentration in ferricreet zone. Concentration of Gold shows great variations. In bed rock it varies between 0.01 ppm to 0.05 ppm, in the weathered zone it ranges from 0.05 ppm, to 0.51 ppm. In the laterite zone the variation is 0.05 ppm to 2.29 ppm. Substantial enrichment below ferricrete zone is a significant feature.

Political ecology of Gold in Goa's mining reject dumps

The ignorance, indifference about and lack of understanding of the presence of Gold and Gold sulphides in Goa's mining reject dumps is a serious mistake. Goa's mistake is importers' net gain and a colossal

Iron ore in Goa is extracted after removing the "overburden", rocky, often lateritic layers with low iron content. Laterite in India contains Gold. Roughly two MT of

overburden needs to be removed to get a single MT of exportable ore. From 1953, Iron ore export began to cross a million MT. From 1971 it crossed 10 million MT. Before "illegal mining" boom took place the quantity of overburden, the reject dumps contained more than One billion MT material. Actual quantity may be much more. Almost all of it is lateritic overburden. It contains about two percent Titanium, 35 to 40 percent Aluminium and among the trace elements- appreciable quantities (in parts per million, about 300-900) of Chromium, Vanadium and Zirconium. Recently we have detected about one percent Gold containing minerals (roughly 100 ppm elemental Gold equivalent) in old reject dumps raising several questions about exporting such valuable material without separating precious heavy metals like Gold. At the importing point the importers must be having the full knowledge that they are getting lateritic low grade Iron ore with extractable –Titanium, Aluminium, Chromium, Vanadium, Zirconium and Gold. The windfall for illegal miners is actually double windfall for the importers. Most of the illegal mining activity has taken place by excavating dead (more than 10 years old) or live (less than 10 years old) reject dumps. Satellite images make it clear that hundreds of old reject dumps have been excavated during past seven to nine years. With just a click of mouse the director of mines could have seen for himself using the free version of Google Earth and its' historical imagery feature, how dead Iron ore reject dumps in Goa's mining belt from Advalpale to Neturlim-Selaulim have been systematically excavated since 2006. The best example is excavation of a massive reject dump from Sanquelim. It had well grown plantation and a small waterbody at the base. There are strong reasons to believe that the export of low grade ore from these old dumps has been a windfall for the importers. China and Japan have heavy metal recovery programmes. The Chinese wish to monopolize the heavy and rare earth metals commodity market and have been aggressively pursuing prospecting for polymetallic nodules on floor of Indian ocean. This news has already sent shivers down India's technological establishment as our own polymetallic nodule mining programme has slowed down. Chinese are much ahead of the rest of the world in metallurgical technology. They have secret processes to extract trace metals from low grade ores. These metals help them in their military and space applications. There is no precise scientific evaluation or costing of exported ores from Goa based on detail geochemical analysis for major (Iron, Titanium, Silica, Aluminium, Phosphorous, Manganese, Magnesium, Calcium), and trace elements (Rubidium, Strontium, Yttrium, Zirconium, Niobium, Barium, Lead, Thorium, Uranium, Scandium, Vanadium, Chromium, Nickel, Copper, Zinc, Platinum, Gold and Silver). Analysts do not publish the values of last three metals for obvious reasons as these are well kept trade secrets. The importers dictate the prices looking only at the Iron ore content-the rest of metals come as free bonus. Both high grade and low grade ores are in demand. The low grade ores have interesting geochemical composition. It can not be considered any more as 'waste'. Actually it is 'misplaced wealth'. There is no procedure or mechanism to follow the fate of the exported ores, especially the low grade ores which may find market in China. The Chinese would never reveal where the ore ends and what they do for internal beneficiation or separation of useful metals. The assumption by exporters is that the ore may be used for steel industry. But the Chinese are not fools to waste useful heavy metals when they have to depend on imports of several metals. Since there are no 'end user agreements' between Indian exporters and Chinese importers, nothing is binding on the Chinese. What Goa and the our country is losing in the process?. First we have right to demand exactly what is getting exported-there should be total disclosure of every ore consignment in terms of it's geochemical composition. The valuation of the

ore should not be based only on Iron ore content but also the content of other metals and trace elements at prevailing market rates. There should be cross verification procedure. Since the content of Titanium, Chromium, Vanadium, Zirconium and Gold is appreciable in so called ore rejects or overburden, there needs to be a total ban on the excavation and export of these ores. At present the ban is not based on this consideration. India is deficient in all these metals-so exporting non ferrous metal containing ores to China is a strategic error. The Chinese must be having a good laugh behind our backs when they look at their rising inventories of heavy metals. With biohydrometallurgical processes making it economical to employ powerful ore leaching microorganisms to separate various trace elements, including Gold- China would derive benefit from Goa's ore imports. There is negligible local commitment for developing eco friendly R & D for local mining industry. The reject dumps were considered for past 45 years as environmental nuisance as these were causing gully erosion during the rains. But with rising Chinese appetite for low grade ores-the 'environmental nuisance' has been converted into " economic opportunity'. But when actual commodity costing is done it would be discovered that the Chinese got the ores from Goa at throwaway prices. The current rates of heavy metals need to be taken into consideration when we examine geochemical composition of exported ores. Even with just 100 ppm Gold content, Goa's iron ore reject dumps would become economically feasible in future for biohydrometallurgical operations. The state government is not responsive on heavy metal reserves policy. The new central act on mining would not address the basic issues. Japan and China hold lessons for us because these countries are experts in metal recycling and recovery programmes. Goa is only bleeding the earth causing environmental and social distress.

Political economy of Gold deposits in Goa:-

So far the discourse was limited to legal, technical, social and environmental issues of mining. But the rationale behind ore exports without scientific costing or evaluation has not been explained. New economy needs new technologies and new policies. Without knowledge based , rational, ecofriendly and people friendly ore excavation and export policy-we would only fuel the geopolitical ambitions of countries like China.

I don't wish to reveal the quantity of exploitable Gold from BHQ derived mining rejects of Goa or estimates of Gold lost due to faulty, outdated policies. This is a colossal national loss considering the present economic recession. About auriferous rock formations, ores, minerals, sands, soils, sediments- the standard policy of central government till 1987 and state government till today is to maintain total silence and follow the four century old Portuguese precautionary policy. The Portuguese policy has been described aptly by famous 16 th century Dutch traveller Jan Huyghen van Linschoten, who had visited Goa in 1583 and wrote an account of his travel- 'The voyage of John Huyghen van Linschoten to the East Indies' published for the first time in English in 1885. He had written in 1583 after touring Goa " "the land itself is very stony and dry having a kind of red earth so that some Italian Alchemists have promised to get Copper and Gold out of the same, which neither the king nor viceroy would ever consent unto, fearing least the report of such treasure would be occasion of greater trouble unto them by their enemies that are around them.". The Portuguese King and his Viceroy in Goa were scared of a Gold rush and attack from enemies. The same concerns continue but the facts are facts. Even without a Gold rush Goa is losing Gold and exporting ores with Gold content. The answer to a possible question –how we found Gold in BHQ ore rejects is simple. You need to specifically look for Gold with an open mind and not from purely a miners', an engineers, ' a geologists'

or a geochemists' angle. Besides one needs to follow the latest global trends in microprospecting of Gold . One needs to be sceptical about absence of data on geochemical analysis of Gold in Goa because there is a conspiracy of silence on this subject owing to the value of the metal. The logic should have been simple. If the auriferous rocks of Goa are similar to Chitradurga then there would be Gold. There had been enough hints in the chapters written by late O.A. Fernandes in the monograph "Natural resources of Goa". There is a lot of information about Gold content in tropical laterite and saprolite. But when a geologist like Mike Widdowson gives a detail geochemical analysis of lateritic profile in Tiswadi (chapter 4 in above book) we wonder about elimination of any possible data on Gold content. This is despite samples being taken from surface to a depth of 34 metres. Why he found 16 other trace elements more important than Gold despite knowledge of Gold content of laterites?.. The conspiracy of silence extends to geological survey of India-GSI. A paper published in June 2009 on soil and stream based geochemical mapping of Goa mentions about geochemical analysis of 200 soil or lateritic samples and 654 stream sediment samples. They analysed 34 trace elements by Plasma Quad PQ1 ICP-MS at National geophysical research institute (NGRI) laboratory. They also claimed that they analysed 152 stream sediment samples from southern parts of Goa for Gold by Atomic absorption spectroscopy(AAS). So far so good. But the paper is totally silent on their Gold analysis. So we are left in dark about Gold content in stream sediments of 152 samples from south Goa. So what happened to this AAS based data on Gold in streams of south Goa?. Did they pass on the information to Goa government or transferred it to private mining companies directly?. If Gold content in these stream sediment was not detected then the authors should have mentioned it in the paper. This is a classic case of public funded government publications where analysis is mentioned but the results are hidden. I strongly suspect that the stream sediments were proved positive for Gold and therefore GSI took a decision to omit the data from the paper consistent with the old Portuguese policy. There is a degree of hesitancy among the traditional geologists to embrace relatively novel areas like geomicrobiology, geomycology, geobotany and nanobiotechnology. Goa's mining industry needs a holistic multidisciplinary knowledge based geomicrobiological paradigm shift because everywhere one looks there are microbiogenic minerals. There are ancient petrified stromatolites in upper reaches of Mahadayai basin and marine fossil beds in coastal areas. Almost all the ores have chemolithotrophic microbes. Available data reveals that from 1951 to 2011, Goa exported about 800 million MT of iron ore. A large portion of the exports have come from BIF-BHQ zone of north Goa. This may account for more than 500 million MT. Since the ores were not subjected to Gold analysis it is difficult to quantify how much has been exported. The iron ore rejects in mines of Goa comprise low grade lumpy ore, low grade aluminous powdery ore, low grade siliceous powdery ore, low grade screen fines and dressed rejects. From the billion MT rejects left behind again it is difficult to estimate total quantity of BHQ overburden. According to Canadian expert on Gold in BIF Professor Wilton, in general, banded iron formations (BIFs) contain between 4 and 30 grams gold per tonne, at least in his country. The BHQ rejects don't have iron content less than 51 percent. Banded hematite quartzite -BHQ has been analysed by Raikar and Sahu for silica, aluminium, Titanium, Manganese, Phosphorous, Calcium, Magnesium and trace elements like Chromium, Cobalt, Nickel, Copper, Zinc and Lead. Sahu and Saraf also reported Lead, Chromium, Zinc, Cobalt, Nickel, Copper and Strontium in BHQ. However since there was no knowledge of possibility of Auriferous chert and bacterioform Gold within BHQ no specific attention was paid by any geochemist to

detect Gold either by XRF, Atomic Absorption spectroscopy or Neutron activation analysis. In dead dumps there would be natural enrichment of the heavy gold fraction as lighter fraction is eroded due to rainfall. In active dumps the Gold content is difficult to isolate. Overall both dead and active mining reject dumps in north Goa can yield enough quantities of Gold exceeding the export value of the Iron ore. It doesn't make any economic sense to keep these dumps idle without separation of Gold required by national economy. But the state government is only focussed on Iron, manganese and Aluminium. The extraction of these ores has ruined Goa. From the ruins, the earth goddess has sent a Golden blessing. From Advalpale to Usgao, there is enough Gold in the mining reject to transform economy and restore traumatised ecology if our government wakes up and acts in my consultation in public interest.

Epilogue

Proof that Goa is indeed "Suvarna-bhumi'

Till December 2010, I was not interested in Gold. But perhaps due to blessings of this land, the Golden secrets were revealed one by one to me. In past 2 years now I have the proof of Gold in layers as deep as 125 metres, in alluvial sand samples, in the paddy fields of Taleigao, in streams of western ghats, in plant litter ash and even in vermicasts created by earthworms and many natural biological samples. Our latest discovery is fungi which are found in mining dumps soils and can absorb and reduce Gold. We have developed simple, rapid techniques to detect Gold and also to produce Gold in laboratory from pure Gold sulphides.

The government tabled a funny reply in the monsoon session of Goa assembly 2012 that it has no reports that Gold occurs in Goa. Then the mines department should have explained why 19 applications for prospecting Gold were received by it. Besides Goa government has also not questioned Hyderabad's Geological survey of India about their data on geochemical analysis of 152 stream sediment samples from South Goa which they had analysed for Gold. The new government has also not shown any sensitivity despite sending all important information on Gold deposits in Goa to the Chief ministers' office and having made two presentations before the CM personally. That explains the conspiracy of silence. I am not suggesting immediate prospecting and mining of Gold. But it hurts me as a patritotic citizen when our iron ore deposits containing Gold are exported to China, when Gold containing river sand and laterite is used for construction without economic evaluation. Our mining policy is not knowledge based and hides more than what it reveals.

Our ancestors were not fool to call this blessed land-Sunaparanta. Now the greed has destroyed the reputation and has made it 'Shunya-paranta". It is however possible that, Sunaparanta would be regained if government and people work together. Today I am in a position to teach a high school student _how to detect Gold from local samples. Gold of Goa is a people's ancestral resource, -let them decide what to do with it.

Annexure (excerpts from Goa Today cover story, March 2011)

How I discovered Goa's Microbial Eldorado

In January 2011 I announced my pioneer discovery of a Microbial Eldorado in Goa's deep metabiosphere, upto 65 metres deep. A metabiosphere is a bygone biosphere-life which doesn't' exist anymore. This evidence comes from island of Tiswadi which is upto 90 metres above present sea level. Despite having submitted an action plan the

state government In January 2011, the mining department has not declared the technical committee or imposed a pre-emptive ban on digging below 60 metres. The discovery was nerve shattering, shocking and path breaking. The discovery was made on December 24, 2010, in the mycology laboratory of department of Botany, Goa University where our project on environment friendly mineral biotechnology is in progress. The first solid , shining, lustrous Gold particle which I found under the Olympus research microscope, was shaped like a typical Christmas star. Since Gold is a noble metal, not oxidized when exposed to elements, its' direct detection is easy. Not only it has unique optical properties-such as brilliance, lustre, reflectance, scattering but its' colour and texture reveals its' purity. That's how people have been finding it directly in placer deposits, in alluvial sands and also as solid nuggets. We subjected the original sample to aqua regia the universal highly acidic solvent for Gold. The test was successful. A miniscule drop of our sample in aqua regia on thermal treatment of 15 seconds left behind a shining film on the slide. Over 600 photographs and 100 n videoclips have been uploaded on the Internet and made available to global peers. The Gold which I found was not ordinary Gold, primary Gold or Gold found in known ores. I wasn't even referring to what was known about surface deposits or primary deposits or claims of Dr. Prabhu or Mr. Hazare or GSI's findings all over India. Still the discovery got mixed up with known findings. People could not understand how bacteria could form Gold that too in deep bowels of Earth. But strangely, as has become a fashion in Goa, even before understanding the advanced science of biochemistry and geomicrobiology of Gold, criticism was launched to discredit the discovery. Subsequently I detected Gold in almost all river sand samples of Goa and soil cores taken from 125 metres depth.

How big is the bacterioform Gold deposit of Goa?

Preliminary estimates show that, a sort of 'river ' of Gold created by some of planets' most ancient microorganisms-at a depth of 60 to 70 metres (average 65 m) lies in a belt of mostly fluvial tilloid deposit, at least two to two half billion years old, in contact with basal metagraywacke. On February 7 th 2011 after recrystallizing the bacterioform Gold from aqua regia solution, I revised my estimates of the total gold reserves in Goa from 3000-6000 metric tones to 100 thousand metric tones. How I have arrived at these figures?. What people generally forget is the high density of Gold-19230 kilograms per cubic metre, so even a small volume of ore sample can give high concentration of the metal in soil or ore. Calculations showed that on weight to weight basis my sample had 5.17-5.20 percent of Gold. I had to recheck this figure several times as it was fantastic. This is a global record for Gold deposit. The best of world's gold deposits rarely have more than 50 ppm of Gold. That would make Goa world's largest hidden resource of Gold. This is new Microbial Eldorado of the world.