

The analysis of Rocks and Soils were subjected to standard sample preparation procedures such as pulverising rock samples in Jaw Crusher and Disc mill, drying soil samples, digestion, obtaining clear sample solution and analysed on ICP-MS for U, Th, Pb, Zn, Cu, Cr, Co, V, Ni & As elements. The analytical data obtained after analysis was subjected to Statistical Treatment of geochemical data. The statistical data in conjunction with Petrography, Geology and Geochemical principles have been used for drawing following tangible conclusions.

## **SUMMARY AND CONCLUSIONS:**

**The Microscopic studies** reveal the presence of alterations such as Sericitisation, Epidotisation and Chloritisation along the Unconformity zone similar to that of Athabasca in Canada and Pine Greek in Australia.

**Surface radioactivity:** The radiometric surveys on basement granite at Chennakeshavulu Gutta near Padhra village at Amrabad outlier (N.16<sup>0</sup> 25' 55" and E 78<sup>0</sup> 50' 40.2") have been undertaken. The radiometric observations have also been made along the unconformity with secondary uranium encrustations in the granite with NNE-trending vertical fracture filled with Chlorite and sericite in the vicinity of unconformity showing hydrothermal nature of mineralization. Basic dykes and vein quartz within the basement granite are also mineralized close to the unconformity. The observed readings in two locations by the differential spectrometer are 195 and 202 ppm. The uranium mineralization is confined to the unconformity at shallow or deeper levels.

**Kankar (Calcrete):** In Chitrial, and Amrabad we find Honeycomb and Nodular type calcrete. In Chitrial area kankar is found near the unconformity zone where Uranium mineralization reported by AMD. Surface radio activity is more in Amrabad area. The surface radioactivity is due to the presence of secondary uranium minerals in granite (Uranophane and Uranyl Carbonate). The Leached Uranium Carbonate from the primary Uranium minerals are trapped in kankar zone. The kankar zone scavenges the further mobility of Uranium

resulting in the accumulation of Uranyl Carbonate in calcrete. Hence the surface radioactivity observed in kankar zone. Kankar formation may play major role in Uranium exploration indicating the U mineralization proximal to the unconformity.

**pH & EC :** As per the United States Department of Agriculture and Natural Resources conservation service norms, the pedogeochemical samples of Chitrial area shows that the pH and EC do not exceed the desirable limit in the soil. If the pH is below the neutral, elements are stable in oxide form. EC shows a reciprocal relation with pH in Chitrial soils. It has been observed that the pH is more than 6.0 in proximity to the unconformity zone and is ranging from less than 6.0 to 4.2 away from the unconformity zone. It can be concluded that Uranium mineralization occurs along the unconformity zone having pH above 7.0 and with low EC. Away from the unconformity zone the pH (around 6) indicates that uranium is mobile and EC increases (Vishnu et.al. 2013).

## **Reconnaissance Survey**

### **Primary Environment of Chitrial**

The correlation of U/Th with other elements such as V, Cr, Co, Ni, Cu, Zn, Pb, Th and U shows very low negative correlations. Other feeble correlated pairs U – Th ( $r = 0.49$ ), U– U/Pb ( $r = 0.286$ ) show that the sampling is inadequate and away from the mineralization to draw good conclusions. Threshold value for Uranium is 11.45 ppm, the sample numbers 5, 6, 10, 31, 35, 39 have value above the threshold values.

Th and Zn are highly mobile and show decreasing nature towards Uranium showing mostly inverse relation with each other.

### **Secondary Environment of Chitrial:**

V – Zn ( $r = 0.87$ ), Cr – Zn ( $r = 0.72$ ) pairs of elements showing best correlation and the V - Ni ( $r = 0.69$ ), Cr – Ni ( $r = 0.56$ ), Zn – Pb ( $r = 0.56$ ), Zn – Th ( $r = 0.68$ ), Th – U ( $r = 0.42$ ) pairs show fairly good correlation in the secondary environment. The threshold value for Uranium is 12.00 ppm. Sample numbers

above threshold value are CTS-1, 2, 4, 7, 10, 13, 40, 42 which are in the vicinity of the sample numbers mentioned above 5, 6, 10, 31, 35, 39

The degree of correlation (r) of uranium with Cu, Zr, and Pb in the primary environment, U with Th in secondary environment is less than 5, which shows that they are decreasing in concentration towards the uranium mineralization.

The uranium shows low negative correlation with V, Cr, Co & Ni in the primary environment and U with V, Cr, Co, Cu show the negative correlation in the secondary environment of the Chitral. This is suggesting the increasing the concentrations away from the uranium mineralization.

The strike of mineralization direction is NE – SW. The anomalous zones are also in same direction in the primary and secondary environments. The As shows good correlation with U in soils. However the As concentration in soils flanks the anomalous U points. Pb concentration in soils shows more dispersion compared to the Pb concentration in rocks. The dispersion of U in rocks and Ni in soils is similar. However, the Ni dispersion in soils shows around the anomalous points of U in rocks.

**Primary Environment of Amrabad:** The correlation studies among the elements of Amrabad area explains that the best correlated of pairs of elements are Zn - Ni ( $r = 0.80$ ), Pb - Ni ( $r = 0.78$ ), U - Ni ( $r = 0.83$ ), U - Zn ( $r = 0.76$ ), U - Pb ( $r = 0.86$ ), U/Th - Cu ( $r = 0.94$ ), the good correlation pairs are Cu - Co ( $r = 0.61$ ), Th - Ni ( $r = 0.64$ ), U - Th ( $r = 0.69$ ), U/Th - Co ( $r = 0.63$ ), U - Co ( $r = 0.55$ ) in the primary environment.

The concentration of U in comparison to rocks and soils show good dispersion in soils as evidenced by concentration of U away from the anomalous zones of U in rocks. Th and U shows similar dispersion patterns, however the concentration of Th is away from the anomalous zones of U. Zn shows a big negative halo around anomalous zones of U. Pb shows positive halo around anomalous zones of U in rocks and negative halo in soils around U anomalous zones in rocks. Ni shows

similar behavior to that of Pb in rocks and soils. The As concentration in soils is more in the vicinity of anomalous zones of U in rocks.

### **Secondary Environment of Amrabad:**

Ni – V ( $r = 0.62$ ), Cu – V ( $r = 0.67$ ), Cu – Ni ( $r = 0.67$ ), U – Pb ( $r = 0.65$ ), U – Zn ( $r = 0.53$ ) pairs show good correlation in the secondary environment.

The degree of correlation ( $r$ ) of uranium with V, Cr, Co, Cu, Ni & Th in secondary environment is less than 5, which shows that they are decreasing in concentration towards the uranium mineralization.

The uranium shows low negative correlation with V, Cr & Cu in the primary environment of the study area. This is suggesting the increasing the concentrations away from the uranium mineralization.

## **Detailed Surveys**

### **Detailed Survey of Chitrial:**

Detailed sampling survey was planned to narrow down target areas, based on the dispersion patterns obtained and observed in the first phase. The detailed grid 0.25 X 0.25 Sq. Km for litho and pedogeochemical sampling has been laid essentially to delineate target areas for detailed exploration for uranium.

### **Primary environment of Chitrial:**

The correlation studies explains that the best correlated pairs of elements in the Chitrial area are Ni – V ( $r = 0.82$ ), Co - V ( $r = 0.70$ ), Ni – Co ( $r = 0.79$ ), U – Th ( $r = 0.74$ ), the good correlation of pair U/Th – U ( $r = 0.68$ ) is showing in the primary environment.

The threshold value is 7.95 ppm and samples having values above threshold value are CTR-31/c, d, 32/d, 39/a, b, c, d, 41/a, b, c, d

### **Secondary environment of Chitrial:**

Cu – Co ( $r = 0.61$ ), Pb – Zn ( $r = 0.61$ ) pairs of elements showing good correlation Co – V ( $r = 0.55$ ), U – Zn ( $r = 0.56$ ), U – Pb ( $r = 0.58$ ), As – U ( $r = 0.57$ ) in the secondary environment of the Chitrial.

The degree of correlation ( $r$ ) of uranium with Cu, Z, and Pb in the primary environment, U with Th in secondary environment is less than 5, which shows that they are decreasing in concentration towards the uranium mineralization. The uranium shows low negative correlation with V, Cr, Co & Ni in the primary environment and U with V, Cr, Co, Cu show the negative correlation in the secondary environment of the Chitrial. This is suggesting the increasing the concentrations away from the uranium mineralization.

The threshold value is 17.39 ppm and CTS-31/a, b, c, d, 37/a, b, c, d, 42/a, b, c, d samples have above the threshold value of the Chitrial.

U is highly mobile in soils compared to U in rocks as evident by more U concentrated zones of soils are away from some of the anomalous zones of U in rocks. Th in rocks show similar dispersion patterns as U where as in soils it is concentrated away from Th anomalous zones of U in rocks. Zn shows good dispersion compared to other elements in rocks i.e Zn decreases towards anomalous zones. Similar trend is also shown by Zn in rocks. Pb concentrations in rocks is more in the vicinity of U anomalous zones where as the Pb concentration is more in soils away from the U anomalous zones in rocks. Cu concentration is more in the vicinity of anamalos zones. As in soils shows good relation to U anomalous zones in rocks.

**Critical ratios:** The geochemical elemental behavior in ratios U/Th, U/Pb against to the uranium values show, that there is constant increase of their ratios as the concentrations of uranium decreases away the uranium mineralization. The ratios shows negative trend with uranium indicating inverse relation. The values of ratios are decreasing towards uranium mineralization that shows negative trend with uranium indicating inverse relation. So their ratios are decreasing towards uranium mineralization. These geochemical behavior ratios can be used to identify location of target mineralization zones in the primary and secondary environments of the Chitrial and Amrabad areas.

## **Comprehensive conclusions:**

The following comprehensive conclusions are drawn for the Unconformity related Uranium mineralization investigations carried out at Chitrial and Amrabad areas of Nalgonda and Mahaboobnagar districts of Andhra Pradesh

1. Sericitization, Epidotization and Chloritization are observed along the Unconformity related U mineralization zone as seen elsewhere in the world.
2. The good radiometric values observed along the unconformity zone with secondary uranium encrustations in the granite (in the case of Amrabad).
3. The surface radioactivity observed in kankar zone. Geochemistry of kankar may play major role in Uranium exploration.
4. The Uranium mineralization occurs along the unconformity zone having pH above 7.0 and with low EC. Away from the unconformity zone the pH (around 6) indicates that uranium is mobile and EC increases. pH and EC shows reciprocal relationship.
5. Signatures of U, Th, Zn, U/Th and U/Pb may be used for the delineation of anomalous zones of Uranium in Chitrial and Amrabad in conjunction with the above conclusions. These conclusions are area specific. These conclusions can also be used in other areas having similar Geological and Geochemical Conditions. We should also consider the peculiarities and special geochemical characters of the other areas where the above conclusions are to be tried.

