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Behavior of Uranium mineralization in Siwaliks of Nangar Nai area; Dera Ghazi Khan

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ABSTRACT: *The uraniferrous fluvial sedimentary rocks exposed in Nangar Nai area, D.G. Khan District run along the eastern margin of Sulaiman Range and make a part of middle Siwaliks. The rocks are of vital importance for uranium exploration. These uranium accumulations are paleo-channel related and occur at places where the paleo-channel is ducking in. The ducking out paleo channels are devoid of subsurface uranium mineralization despite of very good surface signature of radioactivity. The genetic model proposed for the source of these uranium deposites may be attributed to the primary rocks of the Himalayas coupled with volcanic tuff and ash falls derived from the volcanic activities occurred in the northern & western parts of Pakistan. The uranium was liberated from the primary rocks, transported in solution along the fluvial sediments and deposited at suitable locations. Later enrichment accumulations have resulted in the formation of uranium ore accumulations.*

Nangar Nai uranium mineralization is primarily a paleo-channel related ore body that was formed well below the present day water table in the form of a complex paleo-channel cum ground water oxidized leach type sandstone deposit. The uranium was mainly transported and deposited by the paleo-channel and enriched by the accumulation phenomenon. Further enrichment was provided by the indigenous volcanic source. Due to later tectonic uplift of strata a part of the uranium-bearing horizon has been exposed to the surface, which was oxidized and eroded. Major part of the ducking in paleo-channels has developed a redox interface below the water table and resulted in an ore body. Remobilization has caused leaching of uranium from western extremities of the ore body that has been transported to the eastern peripheries in the form of further enrichment on existing ore accumulations. This has resulted in positive disequilibrium of uranium ore.

INTRODUCTION

The Nangar Nai area is situated about 70 km south west of D. G. Khan and links to D.G Khan through Quetta – D.G. Khan road. Topographically, it is low-lying flat area with an average elevation of 472 m above sea level. The area is bounded by Dub Chur nala in the north and Nangar nala in the south.

The uraniferrous fluvial sedimentary rocks exposed in D. G. Khan area make a part of Siwaliks that run along the NNE–SSW trending eastern Sulaiman Range (Fig. 1). Topographically, the area in greater extent is quite rugged with steep slopes and deep cuts. Most of the area consists of different levels of terraces, which are mostly boulder covered. Whole of the area is sparsely vegetated and exerts extreme weather conditions.

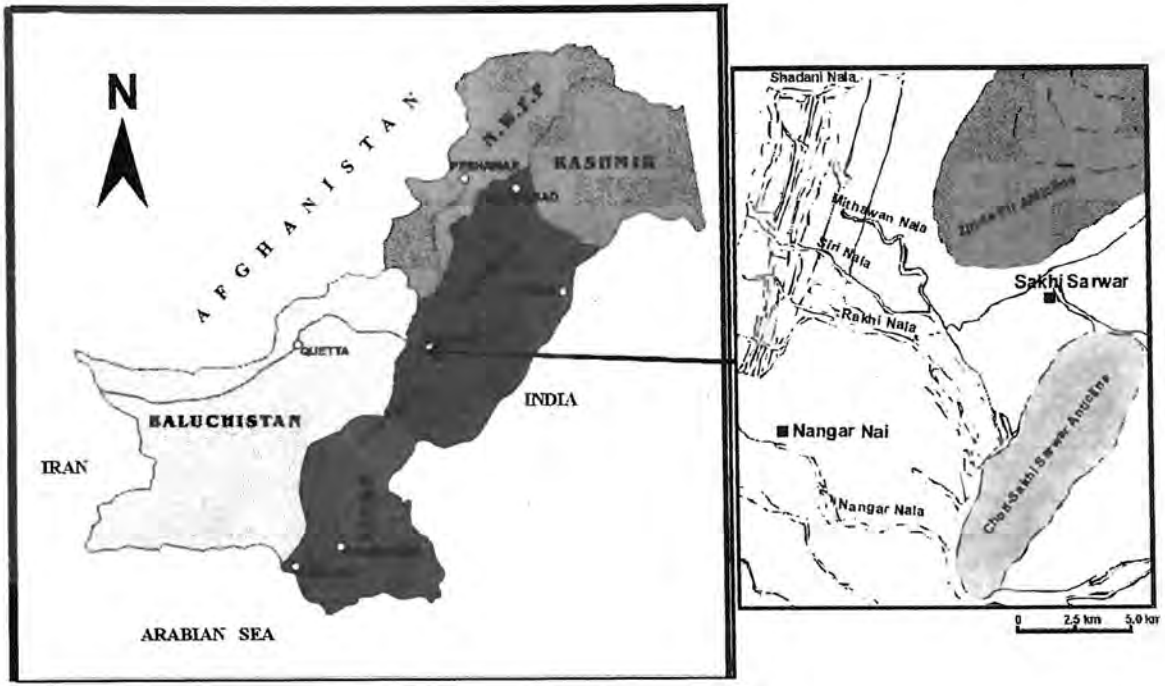

Fig. 1. Location map of Nangar Nai area, D. G. Khan (unpublished report of PAEC D.G. Khan).

The Nangar Nai ore body stretches about 850 m along the strike and 600 m along the dip, southern periphery of the ore body is generally boulder covered.

In this paper the uranium mobilization and concentration in the form of Nangar Nai uranium ore body has been discussed in detail.

GEOLOGY OF STUDY AREA

The Nangar Nai Uranium ore body occurs in the fluvial sedimentary rocks of Pliocene age, which is a part of the middle Siwaliks of the Eastern Sulaiman Range (Hemphill et al., 1973). The rocks consist of alternating sandstones and clay beds where the thickness of sandstone is much greater than that of clay beds. Uranium bearing sandstone, named as Zai sandstone, is about 250 m thick and generally overlies a grey clay bed about 4–5 m thick and underlies a 20–25 m thick brown sticky clay bed. The studied ore body is lying in the middle of Zai sandstone just above a dark-grey discontinuous clay bed about 2–3 m thick (Rehman et al., 1996). This clay bed might have acted as impervious barrier to the migrating uraniferrous solutions and hence provided a place for uranium mineralization. Locally, the host sandstone makes a part of eastern limb of Girdu anticline, which is striking N10° E and dipping 18° SE. The strata also have a gradient of 2-3 % along the strike from north to south. The host sandstone is highly cross-bedded containing pebbles, calcareous nodules and clay fragments. The grain size decreases from bottom to top, depicting typical fluvial deposition (Syed, 1984). The sandstone is medium-to coarse-grained, poorly sorted, friable to moderately hard. It is poorly indurated particularly in the ore horizons as observed through core samples.

The frequency of hard bands is, though, not much higher but their presence has greatly affected the ore horizon and at places these hard bands have bifurcated and weakened the ore horizon (Bhatti et al., 2004).

Geological studies indicate that uranium-bearing sandstone in Nangar Nai area was deposited by braided stream system flowing in a direction from 198°-199° (Zhengbang et al., 1996). It has been observed through field studies that paleo-channel controlled uranium ore bodies are usually found in the subsurface where position of paleo-channel is ducking in. The areas where paleo-channel is ducking out, the uraniferrous rocks have not been preserved and are eroded away.

FORMATION OF NANGAR NAI URANIUM MINERALIZATION

It is now well understood that due to the Collisional events in the northern and western parts of Pakistan the cycle of uplifting, erosion and subsequent re-deposition has started which resulted in the deposition of molasse sediments in the foredeep basin. These molasse sediments are present all along the Himalaya, Karakuram and the ranges in their South and are known as Siwaliks (Sarwar et al., 1979). The uraniferrous molasse sediments of Siwalik group are considered as good host for uranium mineralization. In D.G Khan Division, it has yielded a couple of uranium deposits that are located at the eastern limb of Girdu anticline. These deposits could have possibly been formed due to the erosion of primary rocks in the northern and western parts, which resulted in the transportation of uranium either in solution form or as solid phases and deposited at suitable places within siwaliks.

Other possible uranium source can be the volcanic tuffs sand ash falls erupted during Himalayan orogeny (Hussain et al., 2002). These volcanic ejecta may have remained active during the period and volcanic ash spreaded in the air over thousands square kilometer area. It settled slowly and became part of the Siwaliks, deposited at that time. This is evident from the presence of altered volcanic material in the uranium bearing rocks. Thin layers of altered volcanic materials are present in different areas in uranium bearing sands (Rehman et al., 1996). It can be attributed to the leaching of uranium from volcanic ash and its re-deposition at suitable places in the subsurface. It indicates that Siwaliks of eastern Sulaiman Range, have not a single source of uranium but there might be several minor factors which collectively acted and resulted in the form of uranium accumulation in Nangar Nai area. Local tectonics also played a key role in the deposition and redistribution of uranium minerals. The locally uplifted areas were exposed to erosion and minerals including uranium started migrating in solution form in down dip direction and reprecipitated which resulted in enrichment of subsurface uranium mineralization along the redox zone below the water table.

Nangar Nai uranium accumulation is primarily a paleo-channel related uranium mineralization that exists well below the present day water table. It has a lenticular shape and exhibit erratic distribution hence indicating a complex paleo-channel cum ground water oxidized leach type sandstone deposit. This suggests that the Nangar Nai ore body was initially a conventional paleo-channel type of deposit. Subsequently, due to the tectonic activity the area was deformed which resulted in the uplift and ultimately tilting of the rocks of the area. This tectonic episode exposed the Siwalik rocks in their western extremities at the eastern limb of the Girdu anticline (Zhengbang, 1996). Due to exposition of uraniferrous Siwalik rocks in the oxidizing conditions, uranium minerals started leaching and percolating downward along the dip and were re-deposited at the redox boundary. This behavior can easily be interpreted from the gamma logs. Almost all gamma logs usually have high radioactive peaks and chemical uranium is present against each peak, indicating Paleo-channel type of deposit. But in many cases it is noticed that chemical uranium is also present in the zone below the gamma log peaks against the low radioactive signatures. This suggests the presence of relatively young uranium which might have been precipitated from the uraniferrous solution percolating along the dip.

It has been observed that the remobilization has caused leaching of uranium from western extremities of ore body that might have been transported to the eastern peripheries in the form of further enrichment of existing uranium accumulations. This is evident from the fact that western up-dip margin of the ore body shows negative disequilibrium, whereas down dip central and eastern parts of the ore body indicate positive disequilibrium. The movement of uranium bearing solutions has further enriched the already existing uranium ore in the subsurface. Thus uranium in Nangar Nai area was transported and deposited by the paleo-channel and later on enriched by the re-deposition of uranium minerals from solutions percolating along the down dip direction. The over all disequilibrium of the ore body is 30 % positive, indicating accumulation of additional

uranium in the form of uraninite and coffinite (Hassan, 2001).

Field studies indicate that paleo-channel related uranium mineralization occurs in the subsurface at places where the position of paleo-channel is ducking in, which means that the paleo-channel is going in the subsurface along the dip of the strata and hence, the uranium minerals deposited by the paleo-channel are preserved in the subsurface. Nangar Nai uranium mineralization is, therefore, related with the ducking in paleo-channel. The places where the position of paleo-channel is ducking out even there good surface exposures lack subsurface uranium potential.

CONCLUSIONS

Middle Siwaliks of Eastern Sulaiman Range have vital importance for uranium exploration and have yielded different paleo-channel controlled sandstone type of uranium mineralization at the eastern limb of Girdu anticline. The source of these uranium deposits can be attributed to the primary rocks of Himalayas coupled with volcanic tuffs and ash falls derived from the volcanic activities occurred in the north and west. The Nangar Nai uranium mineralization is a complex paleo-channel cum ground water oxidized leach type sandstone deposit. The uranium deposits occur in the subsurface at places where the paleo-channel is ducking in but the places where paleo-channel is ducking out it is devoid of subsurface uranium mineralization. The over all disequilibrium of the ore accumulation is 30% positive indicating accumulation of additional, relatively young, uranium.

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