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WHETHER TECTONO-MAGMATIC REGIMES OFFER ANY PROSPECTS FOR PRIMARY URANIUM MINERALIZATION IN NORTHERN PAKISTAN

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ABSTRACT

The northern segment of Pakistan inhabits some of the loftiest mountain systems of the world. Nearly forty per cent of the rocks covering the surface area in this terrain are igneous, out of which over seventy per cent belong to the acid igneous domain.

The Late Mesozoic – Cenozoic orogenic events had brought into being some of the major lineaments which have regional dimensions. Magmatic emanations associated with these shears belong to several generations; some of them belonging to the late phases have indicated metallic mineral associations. A few known primary uranium mineralizations in this region are associated with some of these magmatic episodes.

This paper discusses the tectono-magmatic environment of the northern Pakistan and delineates the metallogenic zones under the context of plate tectonics– where favourable conditions may exist for finding primary uranium mineralization.

INTRODUCTION

Uranium exploration in Pakistan has achieved a sound scientific base because of the relentless efforts put up by the PAEC during last three decades, which succeeded in locating bonanzas of secondary uranium in the Siwaliks. There is not much to add anything here than to advocate for bringing into an extensive geological fold the widespread igneous domain in the northern region to accelerate search for primary uranium mineralization.

For this purpose a sophisticated scientific approach is to be made to demarcate the evolutionary history of various magmatic bodies. This type of studies will not only supplement the conventional techniques now in vogue in the country but will also enrich our knowledge on the genesis of ore to discern specific magmatic episodes responsible for inducing primary uranium mineralization.

GENERAL GEOLOGY

A cursory description of the regional geological set up in the northern region is intended here without which the problems and its solution may not be properly explained.

Under the framework of plate tectonics, the northern part of Pakistan is divided into three tectonic domains; The Indo-Pakistan plate, the Kohistan Island arc and the Eurasian plate (Tahirkheli et al., 1979).

The Indo-Pakistan marginal mass is comprised of a thick pile of metasedimentary rocks belonging to the Lesser Himalayan sequence and ranging in age from Cambrian to Precambrian. These are overlain by the rocks of Mesozoic (Triassic, Jurassic, Cretaceous) and Tertiary (Paleocene, Eocene, Miocene) periods with well marked tectonic contacts on the south.

The metasedimentary assemblage is comprised of pelites, psammites and carbonates roughly keeping a ratio of 60:15:25 respectively. The metamorphism in the pelites is of Barrovian type showing progressive increase from chlorite slate in the south to sillimanite-schists and gneisses in the north, in the vicinity of the Main Mantle Thrust (Tahirkheli, 1979).

The igneous rocks dominantly of granitic character form isolated bodies of various sizes intruding the metasedimentary sequence all along the plate margin. Granite, pegmatite, aplite and vein quartz, arranged in descending order of abundance are the principal components of the acid igneous intrusions which range in age from Cambrian to Upper Tertiary. Diorite, dolerite and gabbro constitute minor basic igneous rocks which occur as sills and dykes, intruding both the metasedimentary rocks and the granite masses.

The Kohistan sequence is about 35 km thick and is comprised of metasedimentary and calcalkaline plutonic and volcanic rocks which are divisible into the following nine mapable units.

i. Jijal ultramafics,
ii. Kamila amphibolites,
iii. Bahrain pyroxene granulites,
iv. Kalam Group,
v. Dir Group,
vi. Deshai Diorites,
vii. Ladakh Igneous Complex,
viii. Greenstone Complex, and
ix. Ophiolite melange.

For a detailed description of these rocks the reader is recommended to go through a recently published book on Kohistan by Tahirkheli and Jan (1979).

The Eurasian marginal mass is comprised of two principal rock types; a meta-sedimentary Darkut Group and an igneous Karakoram Granodiorite.

Darkut Group is over 1500 m thick sequence and is comprised of three lithologies, e.g. a dominantly pelitic bed at the base, 150–200 m thick bed of very coarse marble in the middle and semi-to-medium crystalline limestone with inter-bedded slates on the top. The last one has yielded fossils of the Carboniferous age. These rocks border the Main Karakoram Thrust along which the Darkut Group has obducted on the Kohistan sequence. Garnet-staurolite grade metamorphism has been recorded in the pelitic part of the Darkut Group, north of Minapin, in the upper reaches of Hunza Valley.

The Karakoram Granodiorite batholith forms an arcuate bend and separates the Darkut Group from the rocks of the northern Tethyan folded belt. Its uninterrupted E-W extension has been marked along the northern fringe of the Karakoram between Mastuj in Chitral in the west to eastern extent of Shyok Valley in Pakistan in the east. The dominant rock in the batholith is granodiorite which is grey, very coarse grained and generally massive, though in the vicinities of the southern and northern margin, near the contact with the country rocks, it indicates slight foliations. In the mineral assemblage biotite is quite dominant. The other igneous bodies mostly in the form of veins and veinlets found intruding the granodiorite constitute granite, pegmatite, aplite and vein quartz belonging to acid igneous domain and dolerite, diorite and gabbro among the basic suite. These acid and basic intrusions belong to different magmatic episodes and emanated subsequent to the granodiorite phase.

MAJOR FAULT TECTONICS AND RELATED MAGMATISM

The widespread magmatism in the northern region is associated with various orogenic episodes, some of them as old as Precambrian and others as young as Pliocene/Pleistocene periods. The older episodes are associated with the Indo-Pakistan and Eurasian plates whereas the younger ones occur in all the three earlier mentioned tectonic domains.

To decipher the tectono-magmatic environment, the major fault tectonics and related magmatism are enumerated below (Table 1) from south to north.

TABLE 1. MAJOR FAULT TECTONICS AND ASSOCIATED MAGMATISM

Major Fault Tectonics	Associate Magmatism
A. Indo-Pakistan plate	
i. Marghala Thrust	Barren, no magmatic association
ii. Main Boundary Thrust	Malakand Granite (Khan, 1955)
iii Gadun Fault	Ulta Granite
iv. Reef Belt Fault	Ambela Granitic Complex and Swat Granitic Gneisses (Martin et al. 1962)
v. Lakrai – Tarbela Thrust and Peshawar Vale Rift Zone	Koga Alkaline Complex (Siddique 1967) Shewa Formation (Martin et al., 1962) Warsak granite (Ahmad et al., 1969) Mansehra Granite (Shams, 1961)
B. Kohistan Island arc	
i. Intra-oceanic subduction on the northern margin of the Indo-Pakistan plate during Late Jurrasic Early Cretaceous, which gave rise to creation of Kohistan Island arc	Kamile Amphibolite, Bahrain Pyroxene Granulites (Tahirkheli and Jan, 1979)
ii. Main Mantle Thrust	Ladakh Igneous Comples (Tahirkheli and Jan, 1979) Utror Volcanics (Majid et al., 1979) Deshai Diorites (Jan, 1979) Greenstone Complex (Ivanac et al., 1956)
C. Eurasian plate	
i. Main Karakoram Thrust	Karakoram Granodiorite Batholith (Ivanac et al., 1956)

KNOWN PRIMARY URANIUM MINERALIZATION

The primary uranium mineralization so far reported in the northern region is located in the following areas:

i. Uraninite-bearing pegmatite in the vicinity of Oghi.
ii. Biblinite-bearing pegmatite in the Nilishang area of upper Hazara.
iii. Uraninite-bearing pegmatite in the vicinity of Thakot.
iv. Uraninite-bearing pegmatite in Kaghan in Hazara.
v. Uraninite-bearing pegmatite in the Bunji area.

Among the above mentioned mineralizations, i-iv are located in the marginal mass of the Indo-Pakistan plate. The last mentioned occurs in the Main Mantle Thrust zone lying within the Kohistan arc. Besides, many more such pegmatite bodies occuring in the widely scattered areas in Azad Kashmir, Upper reaches of Shigar Valley in Baltistan and in the vicinity of Astore have also indicated uranium mineralization. Most of them are located on the southern marginal mass of the Eurasian plate. These pegmatites are awaiting a thorough probe for the identification of the uranium mineral present before formalizing their status in the comity of primary uraniferous igneous domain.

TECTONO-MAGMATIC ENVIRONMENT AND FUTURE STRATEGY

The cursory field evidences discussed earlier and supported by the regional distributive pattern of uraninite in the river alluvials, one may safely conclude that the primary uranium mineralization has a strong hold in the northern region. At least one magmatic phase, that of pegmatite and possibly more appear to be involved in inducing this mineralization.

Pegmatites have remote chance to yield commercial grade uraium, nevertheless the presence of uraninite is a proof that the inherent molten chamber from where the pegmatite and other magmatic bodies had derived their material, contained uranium alongwith the other elements.

Major magmatic phases are associated with the alpine orogenies which have left deep imprints in the northern region. Thus, besides the older magmatic bodies belonging to Cambrian, there are others which belong to post continental collisional period, emanating during Early and Late Tertiary period. The earlier ones are associated with the Indo-Pakistan and Eurasian continental margins–whereas the latter are found strewing the rocks of all the three tectonic domains. The uraniferous pegmatites belong to the latter episodes. However uraninite or other primary uranium occurrences in the older magmatic phases cannot be ruled out.

Among the three granite phases reported by the earlier geologists in the Himalaya, tourmaline granite contains metallic mineralization. This granite phase is post-granodiorite (Ladakh and Karakoram) and has quite widespread distribution in the northern region. This has been cursorily examined in some major valleys and bulk of it so far remains unchecked. This granitic phase is worth studying for primary uranium mineralization.

Two major magmatic bodies of Kohistan and Eurasia are the Ladakh Granodiorite and Karakoram Granodiorite, both of them having batholithic dimensions. These two batholiths were studied to decipher their tectono-magmatic environment. In the Karakoram batholith some eight magmatic phases have been differentiated (Jan, pers. com.) which from early to late are: granodiorite – hornblende pegmatite – aplite – biotite granite – muscovite pegmatite – aplite – leucogranite – aplite/quartz. The earlier two magmatic phases are deformed whereas one granitic phase (biotite granite) is associated with the east-west trending fractures as observed in the adits opened for gem mining near Ganesh in Baltit.

The Ladakh batholith represents minimum six intrusion phases in the vicinity of Gilgit – Indus rivers confluence and 7–8 (including basic bodies) east of Skardu in Baltistan. Here earlier 2–3 magmatic phases are deformed.

This study may still be considered immature but it does throw some light on various tectonic episodes and related magmatism in the northern region.

PAEC has already extended their work in the northern region. But keeping in view the extent of the igneous domain, it may be considered inadequate to reach to a concrete and conclusive result. It is still in infancy to comment anything about the scope of primary uranium mineralization in the northern region. This part of the Eurasian–Indo-Pakistan plates has remained a positive area for supply of uranium while being unroofed during Miocene – Pleistocene orogenies – which is now being found stored in the terrestrial deposit of Siwaliks.

The tectono-magmatic environment is quite favourable in the northern region and justifies a thorough check to unravel its uranium wealth. Besides the conventional techniques now in vogue in Pakistan, it is necessary to opt for other methods which will not only supplement this effort but will also bring sophistication in exploration. Thus detailed studies on petrological, geochemical and tectonic controls are the requisite tools for the identification of uraniferous phases and delineating the favourable zones in the vaste igneous terrain in the northern segment of Pakistan.

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