PHOSPHATE DEPOSITS OF PAKISTAN

BY

S. TAYYAB ALI SHAH

GEOLOGICAL SURVEY OF PAKISTAN

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Abstract

This report presents in brief a general review of the phosphate exploration activities in Pakistan.

Except the Hazara District Phosphate deposits of the Kakul-Mirpur-Dalola Basin, there is at present no deposit of economic importance, although the distribution of phosphate material in the form of nodules, lenses and disseminations is described from the Miocene to the Cambrian, rocks units.

The stratigraphy of the Hazara phosphate deposit has been discussed in this report alongwith its chemical and mineralogical composition. Hazara phosphate is a marine pelletal phosphorite associated with silica, chert, dolomite and minor iron. It is probably of Cambrian age.

The reserves of Phosphate rock in Hazara are of the order of 20 to 30 miilion tons of all grades. (surface estimates). Detailed work is still needed to prove this figure.

At present Pakistan is importing phosphate rock from Jordan to meet requirements of its super phosphate making Plants at Lyallpur in the Pnnjab Province. Experiments on the utilization of Paleozic phosphorites of Hazara are being conducted to replace the Jordanian ore, which is costing Pakistan Rs. 12,000,000 in foreign exchange annually and will increase to 140,000,000 rupees by 1977.

II. HISTORY OF PHOSPHATE INVESTIGATIONS

In Pakistan work on phosphate investigations was started as early as 1887 when Warth, Geological Survey of India, found phosphatic nodules having 30% P_2O_5, in the shales above the coal in the eocene

strata of the Eastern Salt Range in the Punjab. The quantity of this material was not sufficient to warrant any economic development.

Phosphatic nodules were later found in the upper Cretaceous shales from Pabni Dhora to Shah Bhilawal, a distance of 40 miles, along the Pab Range in Las Bela District, Baluchistan. The samples collected from Pabni Dhora showed phosphate content upto 3.25% P_2O_5.

M. I. Ahmad, Geological Survey of Pakistan, reported occurrences of phosphatic nodules over a wide area in Nari Shales between Domanda Post and Baska on the road to Mughal Kot, D.I. Khan District, North-west Frontier Province.

Phosphatic nodules have been reported by A.N. Fatmi, Geological Survey of Pakistan from Uch Khwar Nala, 3 miles southeast of Nizampur (33°47'30":72°01'30"), Peshawar District. They occur in the greenish sandy carbonaceous shale of Lower Cretaceous age. The chemical analysis shows 35.2% tricalcium phosphate. The nodules are too few to be of economic value.

M. A. Wahid, Geological Survey of Pakistan, carried out geochemical prospecting during the year 1964 and established a zone of phosphatic rocks in the Paleocene strata of the Campbellpur District and Nizampur area in Peshawar District.

Anthony Stannin, United States Geological Survey and S. H. Mirza, Geological Survey of Pakistan did fairly detailed examination of the various localities to check the phosphatic distribution. The results however were not encouraging as is evident from the remarks of the author in their report *i.e.*, "None of the formation in the four principal areas investigated and described in this report contains sufficient deposits of phosphatic nodules to warrant mining".

Meissner, United States Geological Survey, as a result of (follow up on the work of M.A. Wahid) detailed investigation in the Nizampur area recommended more work in the Cretaceous Units east of Nizampur and north of the Indus River.

From April 9 to May 5, 1966, R.P. Sheldon of the United States Geological Survey, accompanied by the author and A.N. Fatmi, examined the miogeosynclinal Tertiary rocks in the Nammal Gorge of the Western Salt Range, the eugeosyncline Tertiary section in the Sulaiman Range west of Dera Ismail Khan, the Cretaceous rocks in the Chichali Pass section, the Nathia Gali-Bagnoter section, the Bagh-Kala Chitta

Range section, the Moro-Bolan Pass section, the Brewary Valley section, the Pabni Chowki-Pab Range section, the Dhana Nai-Thal-Kohat section and the Mughal Kot section ; the Jurassic rocks in the Nammal Gorge, Chichali Pass, the Nathia Gali-Bagnoter area, the Bagh-Kala Chitta Range and the Mughal Kot area and the Devonian rocks east of Peshawar. As a result of this reconnaissance exploration, Sheldon observed that it seems unlikely that the lower Tertiary-Cretaceous phosphogenic province of the Middle East extends into West Pakistan, but the Jurassic phosphogenic province of the Himalayan foot hills may extend into West Pakistan. It is also possible that the Devonian phosphate rock of Iran and the lower Paleozoic phosphate of Western India extend into Pakistan.

During March 28 to May 25, 1968, an appraisal of the phosphate potential was done by J. W. Mytton of United States Geological Survey assisted by S. H. Gauhar, Geological Survey of Pakistan. A number of previously investigated occurrences were examined by this party. These localities provided sufficient field evidence which helped Mytton to make a reasonable evaluation of the phosphate potential of West Pakistan and observe that 'In conclusion, the probability of finding commercial phosphate in West Pakistan is slight ; however, many areas have still not been investigated either because of their remoteness or because they are under tribal confrol'.

During 1967, M. A. Latif of the Punjab University collected the 'peculiar' looking rock from his Ph. D., thesis area in Hazara District and while testing these in West Germany found it to be a phosphate rock with a 30.63% P_2O_5 content. He verbally communicated that this rock was briefly described in his thesis.

During 1971 ; phosphate investigations work was taken up by a number of geologists. S. Ikramuddin Ali, Geological Survey of Pakistan, carried out phosphate investigation in the Hazara District in the same year and in a written communication to the author described the phosphate deposits of Hazara as follows :

'Phosphate deposits have already been located by the author in Hazara in Sirban formation (Permian) near Kakul (Lat. N. 34°14 : Long. 73°17'); Langar Ban (30°17'30" : 73°20') ; Chura Gali (34°18'30" : 73°21' 30"). The thickness of phosphate beds at Kakul is 5 to 10 feet. As the area is tightly folded and faulted it is difficult to give estimates of reserves at this stage of investigations. However, the Langar Ban

deposit alone is in the range of several million tons (2—5) million tons. Phosphate content in the above named deposit ranges between 25-38%.

During the same year R. A. Khan Tahirkheli, Head of the Geology Department, Peshawar University, undertook examination of the phosphate deposits in the Hazara District and contiguous areas, with the help of his students. This project was aided by the PICIC. He has published (1972) the results of his investigation in a report entitled 'Phosphate Occurrences in Hazara and other continguous areas in N.W.F.P. and Tribal areas'. Under conclusions the author observes that "on the basis of these results a further study necessitates, a detailed investigation of Kakul, Mirpur, Mohammadagali and Tanakki sections in Hazara District for evaluating economic grade of P_2O_5". On the basis of these results, a fairly extensive area in the northwest West Pakistan appears to be underlain by the rocks which may be homotaxial to the Abbottabad Group. He also forecasts the finding of the phosphate rocks in the strata of Alozai Group and Shirinab formation which are the oldest (Permo-Carb?) rocks in the Baluchistan Province".

During 1971, Government of Pakistan sent a Delegation (Comprising the author as Leader and M/s Waheeduddin Ahmed, Director and N. A. Bhatti, Assistant Director as members) ro participate in the activities of the CENTO WORKING GROUP ON PHOSPHATES. The purpose of the CENTO activity was to conduct a study of the known phosphate deposits of the CENTO countries and make necessary recommendations for further exploratory and exploitory work in each country. The GROUP submitted its report to the CENTO Secretariat with the request that each CENTO Country implements its recommendations.

Field investigations were carried out along the lines of recommendations of the *Cento working Group on Phosphate* in all Provinces of Pakistan, and their results are discussed in the following pages :

III. GEOLOGY OF PHOSPHATE DEPOSITS

(a). North West Frontier Province

(i) Hazara District

An important discovery of marine phosphorite in the Cambrian rocks of Hazara District opens up the possibilities of finding phosphate rocks of commercial potential in Pakistan. This Cambrian phosphorite is fairly extensive in the Hazara District and is traceable along the

Syntaxial bend of the Himalayas into Azad Kashmir near Muzaffarabad and probably south-wards through Kotli into the Indian held Kashmir.

The phosphorite is found in the dolomite and cherty dolomite member of the Abbottabad Formation. This dolomite member is about 2000 feet thick. Phosphorite in the form of lentils, stringers and beds is encountered in the upper about 200 feet of cherty dolomite. The rocks lying immediately above the phosphorite were deposited under shallow water conditions.

Three sections, the representative exposures of the Cambrian phosphate of the Hazara District in the 20 miles long section, investigated during 1971-72 field season are ;

a. **Kakul-Mirpur Section**
b. **Lagarban Section**
c. **Bagla Gali Section.**

Physico-Chemical Characteristics of Hazara Phosphorite

Phosphorite is found in the cherty dolomite. It is pelletal medium grey to dark grey and sometimes black in colour. Pale bluish and bluish white phosphate bloom is noticeable in the entire area.

Phosphate in this area is mostly in the form of collophane which usually occurs as pellets. Dahllite is sometimes associated with these collophane pellets. The gangue minerals are chert, dolomite, calcite, limonite and some hematite and silica.

Radiometric surveys of the phosphorite outcrop indicate insignificant radioactivity. The P_2O_5 determinations of about 140 specimens give a range of 12% to 40%.

Notholt in a recent communication while commenting on the analysis of phosphate specimen from Kakul, done by the Geochemical Division of the Institute of Geological Sciences, London. says that 'the Seml-quantitative X-ray fluorescence analysis showed 36.6 percent P_2O_5 and less than 1.0 percent Al_2O_3. Differential thermal analysis supports the view that, inspite of the chemical analysis by the West Regional Laboratories, Lahore, indicating 39.4 percent Al_2O_3 the phosphate mineral is apatite and not a member of the crandallite group.

Reserves and Economic Feasibility

Bhatti after conducting a detailed survey of the Kakul-Mirpur phosphorite deposit reports that thickness of the phosphorite itself is

rarely two to three feet and its smaller thicknesses are usually intervened by thick dolomitic rocks. Smaller thicknesses of the phosphorite lentils scattered within the wide range of the horizons and their limited lateral extensions render it disappointing for its economic feasibility. Moreover, the phosphate rock is quite hard, compact and siliceous which will be comparatively expensive to work for its product.

This position of reserves is not very encouraging. The reserves were calculated by surface studies and very shallow pitting.

During 1973, a large open cut was made exposing the entire thickness of the Kakul phosphorite bed over a lateral distance of about 1500 feet. The reserves tabulated above would need revision when drilling has determined the down dip extension of the phosphorite bed. The reserves in this area alone may be of the order of rwo to three million tons of phosphorite of all grades.

Recent investigations (1974) have revealed a small deposit of 1.8 million tons (approx.) to a workable down dip depth of 300 feet in the Sirban Hill near Abbottabad. P_2O_5 content ranges from 5% to 32%. (Rapid Field Tests).

It may also be pointed out that the phosphorite horizon is traceable from Kakul to Dalola over an approximate distance of 20 to 25 miles. Hence the reserves would be fairly large. Detailed geological mapping supported by drilling should be completed on a priority basis to arrive at a final figure of reserves.

Exploration for Phosphate

The phosphorite outcrop was discovered at Baglagali during the reconnaisance traverse. The phosphorite horizon at Baglagali is about 16 feet thick and P_2O_5 content varies from 10 to 20 percent within its sub units. The phosphorite bearing rock makes an isolated exposure. The area is structurally highly disturbed and the later extension of the phosphorite horizon is yet to be traced.

Quite exciting and probably the most promising exposure of the phosphorite was discovered at the end of four days continuous hard climbings at a few miles west of the Dalola along the norther slope of Naroke-de-Katha. The phosphorite horizon is about 50 feet thick here and is composed of greyish pale, pelletal, granular and friable phosphorite. The phosphorite horizon could not be sampled because of the

limited time then at the disposal of the party, but the physical appearance and substantial thickness of the phosphorite horizon definitely hold a good promise for the discovery of potential phosphate deposit in the area.

ii. Peshawar District

The Chichali Formation between Thal and Nizampur along the southern flank of the Kohat Range contains four deposits :—

(*i*) East to West of Nizampur.
(*ii*) Kohat.
(*iii*) South of Fort Lockhart.
(*iv*) Darsamand northeast of Thal.

High glauconitic basal beds of Chichali Formation cropout in a section 17 feet thick at milestone 10.7 on the road from Hangu to Fort Lockhart. The rocks in the lower seven feet are extremely glauconitic and contain abundant belemnites at several horizons. Many black nodules are disseminated through this interval. The upper part of the outcrop has a lesser amount of nodules.

The phosphate zones were detected in Cretaceous rocks and one was found in rocks of Jurassic age.

The top zone is a limestone with an average thickness of 7 feet. At the top of this limestone there is nodular conglomeratic layer ranging in thickness from $\frac{1}{2}$ to 2 feet. This layer Is phosphatic and contains 10-15% P_2O_5.

The middle zone approximately 50 feet below the top zone is thin bedded, glauconitic and in places calcareous sandstone with an average thickness of 55 feet. P_2O_5 content is 5% although it rises to 12% near Nizampur.

The bottom zone (100 feet below the top zone) is 10 to 15 feet thick at the base of the Chichali Formation. Phosphatic nodules $\frac{1}{2}$ to 4 inches in diameter are found scattered through grey or greenish shale, sandy shale and sandstone. P_2O_5 ranges from 5 to 15%. The richer phosphate locality in the Nizampur area, in the lower nodular shale zone, is in the area from Khwari beginning at about one mile to the south of Nizampur-Attock bridge road at the contact with the Jurassic limestone and extending eastward to Gandab Khwar. The zone is 10 feet thick and extends to about six miles. P_2O_5 percentage ranges from 10-15%.

iii. Kohat District

Highly glauconitic basal beds of the Chichali Formation cropout in a section, 17 feet thick at mile post 10.7 on the road from Hangu to Fort Lockhart. The rocks in the lower 7 feet are extremely glauconitic and contain abundant belemnites at several horizons. P_2O_5 content ranges from 0 to 25% (Meissner).

iv. Other Areas

Abbottabad formation is traceable in a number of areas of the Hazara, Peshawar, Mardan and Swat Districts of the N.W.F. Province. Hence the possibilities exist for finding the phosphorite horizon in these areas some of which may have much better accessibility than the Hazara District deposits.

The age of the Abbottabad Formation on the basis of recently identified fossils (spicules) have been determined as Cambrian.

Phosphatic rocks have recently been found by Ibrahim Shah in the Paleozoic section of the tribal areas of Khyber Pass. Their extension northeastwards into Chitral and Gilgit and southwest and westwards into Afghanistan deserve careful examination. Relationship of the Devonian phosphate bearing strata of Elborz Mountains of Iran with the Afghanistan-Khyber Pass--Chitral and Gilgit rocks of the same age needs to be investigated thoroughly.

b. Punjab Province

i. Jhelum District

The Patala Formation of Paleocene age between Khewra and Khairabad contains black phosphatic nodules where P_2O_5 content ranges between 10 to 25 percent, but these nodules are sporadic in occurrence and cannot be relied upon for any commercial exploitation.

The author during the course of recent (1974) investigation found that the Patala shales in Sammewal area of Khushab District, contain in their lower part below the coal, calcareous sandstones which have lenticles of high grade marine phosphorite (30% P_2O_5). Lenticular pebbles appear to have been derived from a source not very far off.

Waheeduddin and Cheema have also collected calcareous sandstone samples containing small nodules of marine pelletal phosphorite from Bakrala ridge which appears to be an eastern most extensions of

the Salt Range. The nodules contain 20-25% (field test) of P_2O_5 and are very likely from the same horizon of Patala Shales. Patala shales are very thin in this section of Bakrala ridge.

The author checked the exposures of Cambrian Jotana Dolomite (old name Magnesium Sandstone) along the Choa Saidan Shah—Khewra road and found 5-10% P_2O_5 in the upper part of this formation. Further examination of this formation is recommended.

Five feet thick strata, near Gali Jagir in the Khair-e-Murat Range of phosphatic material in the Eocene Badhrar formation are reported indicating 15 to 20% P_2O_5 content.

M. R. Cheema found a twenty feet thick bed containing 20% P_2O_5 in the Chorgali rocks near Dhok Miki. He also found near Fateh Jang in the early Murree formation phosphatic rocks which on rapid tests gave 10% to 20% P_2O_5. Detailed investigations are underway in these areas.

ii. Cambellpur District

Phosphate bearing limestone found near Chhoi Rest House on the left bank of the Indus River in the Campbellpur area belongs to the upper Cretaceous Kawagarh Formation. The structure in this area is complex and due to the folds and faults the rocks are repeated. The phosphate bearing limestone is 8 inches thick and is overlain by marly shale ; there is no trace of the upper phosphatic limestone bed. There are limonitic and hematitic concretions with the dark phosphatic material. It is evident that the character of the phosphatic zone of the basal Kawagarh changes laterally because at no two localities are the phosphate bearing limestone the same .

iii. Dera Ghazi Khan District

Phosphatic material has been found in the various formations exposed along the Rakhi nala from Rakhi Gaj to Fort Munro.

(*a*) The first phosphatic material is encountered in a shaly horizon in the upper part of Chitterwata formation (oligocene), about 20 feet below the Siwalik-Chitterwata contact. P_2O_5 content is about 20%. Thickness of the phosphatic bed ranges between 10 inches and 12 inches and it is exposed over a lateral distance of about 1200 feet along

the strike. Strike is N20°E and dip is 65°E. The shale found above and below the phosphate bed is also phosphatic and contains phosphatic nodules which are more frequent in the shale zone of 3 feet immediately overlying the phosphate bed. Rough estimate of the frequency of the nodules is about 50% of the shale (Habib Abbas 1972, Fig. II).

(*b*) The phosphatic nodules bearing shales at the contact of Dunghan (Paleocene) and Ghazij Shale (Eocene) are exposed near Rakhi Gaj. P_2O_5 content of these nodules ranges from 5 to 20 percent.

(*c*) At Fort Munro the Paleocene formation equivalent to the Moro formation of Baluchistan is found overlying the Pab Sandstone of Late Cretaceous age. The thickness of this formation is about 800 feet. It is composed of siltstone, sandstone and limestone with minor bedded chert and dark grey shale. This section at Fort Munro is weakly phosphatic at places.

c. Baluchistan Province

i. Loralai District

The author demonstrated in the field the techniques, usually employed for recognising the phosphatic rocks ro a team of geologists engaged in photogrammetric interpretation and mapping of the Sulaiman Range. These geologists later discovered in the Paleocene rocks exposed between Rakhni and Bar Khan phosphatic horizons which merit detailed evaluation.

Moro Farmation (Paleocene)

Moro formation can be broadly divided into lower and upper parts. The lower part begins with a $\pm$ 45 feet green-yellow shale containing rare *venericardia beaumanti* an index fossil of basal Paleocene rocks. The shale contains chert nodules and phosphatic nodules of less than an inch to a few inches diameter.

The dark brown massive sandy limestone often contains beds mottled with dark green and maroon colours which have poor phosphate content. Some beds with a conglomeratic texture contain grey, pale grey and white patches, gravels and small pebbles of phosphate rock.

One lenticular bed of such conglomeratic texture was found in the northeast of village Bandat (northeast of Bar Khan) containing grains, gravels and pellets of phosphorite.

Petrology

The phosphorite is mostly of primary origin. Detrital variations such as glauconitic, arenaceous, oolitic pebbly and nodular are predominant. In some thin sections organic phosphorite is identifiable.

There is abundant hematite in a carbonate matrix with many quartz grains. Phosphorite is minor 20.

Chemical Analysis

Only one hand picked sample from Besti Khamis area of Loralai District has been analysed. It contains 10.95% P_2O_5, silica 40% and very high iron percentage.

ii. Zhob District

During January 1972 the author in the company of Kidwai and Fatmi while examining the Permo-Triassic exposures near Gawai in the Zhob District, found phosphate (8% P_2O_2 Field tests) in the Shirinab formation upper Triassic exposures of thin bedded dark flaggy siltstone (about 30 feet thick) with thin bands of chert.

Phosphatic nodules have also been reported from the Mughal Kot formation of Late Cretaceous age in the Karim Kach Khwar east of Kurgali. The P_2O_5 content is 5%.

iii. Las Bela District

The Pabni Chowki and the Naka Pabni Levy Post phosphate occurrences are in the lower argillaceous section of the 'Jakkhar Group' that overlies the Pab Sandstone.

d. Sind Province

i. Mirpurkhas District

Investigation conducted in 1971 to establish the continuity of phosphorite of Birmania formation (India) into Pakistan, did not lead to any encouraging results.

ii. General Activities

During 1971-72 field season, the Foreland basin of the Kirthar Laki Ranges of Sind and part of the Axial belt Karachi and Pab Range

(Naka-Pabni-Saruna-Khude) were extensively searched for marine phosphorite. No commercial grade phosphorite has been located so far.

So far, the Foreland basin of Sind which falls on the western edge of the Indian Shield; has yielded no clue for locating commercial grade phosphate deposits except minor indications of sporadic nature in the Miocene, Eocene, Paleocene, Cretaceous and Jurassic lithostratigraphic units. This appraisal, however, does not rule out the possibility of finding exploitable grade of phosphate deposits of platform type in these areas.

iv. Conclusions and Recommendations

From the aforesaid appraisal of the field investigations for phosphates in Pakistan, it is evident that chances of multiplying the known reserves of Cambrian marine phosphates in the area between the Muzaffarabad High and Sargodha High, are fairly promising. The recent surveys have however indicated that the commercial grade marine phosphorite deposits are thickly deposited in the Hazara District. It is extremely difficult to arrive at any accurate figure as regards the total mineable reserves as the rocks are severely folded, faulted and structurally complicated. So it would be essential to undertake detailed evaluation, section wise, as has been done by Bhatti and Hussain in the Kakul-Mirpur area. Cambrian lithology of the Hazara District extends into Swabi, Malakand and Swat where the rocks are metamorphosed : their continuation into Azad Kashmir area over the Syntaxial bend of the Himalayas in more or less normal and little effects of regional metamorphism are noticeable. These units are traceable near Kotli which is about 60 miles southeast of Muzaffarabad. The intervening areas between Muzaffarabad and Kotli is occupied by a thick sequence of Siwaliks and Murree formation.

In the Khyber Pass and the tribal areas north and south of it, recent work by Ibrahim Shah, Tahir Kheli and others has revealed a very important Paleozoic section. Whether this is homotaxial equivalent of the Hazara Paleozoics needs to be established. Ibrahim Shah however reports minor phosphate indications in certain beds of the Ali Masjid formation which has been assigned Carboniferous age (verbal communication).

Other areas where a careful search for phosphates should be undertaken are the Silurian-Devonain rocks of Chitral District and Permo-Carboniferous Complex on the north and south of Karakoram massif in the Gilgit District.

South and southeast of Hazara the severe folding and faulting of rocks is much iess due to their distant location from the main axis of Himalayan Orogeny, hence the phosphorite deposits if any would be less disturbed and simple for estimation of reserves. The rocks of Paleozoic era are however deep buried in the Kala Chitta Range but they are exposed in the Salt Range with a fairly changed lithology. In these two parallel ranges which are closer to the Sargodha High, the phosphatic material has been found in the Oligocene, Miocene, Eocene, and Cretaceous rocks with minor traces in the Permian & Cambrian units of the Eastern Salt Range. Some concentrations in the Oligocene, Miocene and Eocene are promising but their commercial potentfal is still not yet established.

In the Sulaiman Range where most of the material was derived from the Indian Shield, the eastern limb is almost barren with only minor indications in the Paleocene in the form of phosphatic nodules and somewhat interesting concentrations of lagoonal environment in the Chittarwata formation of Oligocene-Miocene age. Along the western limb of the Sulaiman Range some promising clues of phosphate rocks have been established in the Paieocene rocks exposed between Rakhni and Bar Khan, Loralai District of Baluchistan.

A study of the Moro formation in the Moro-Bolan Pass section by Sheldon accompanied by author in 1966 revealed that ''this formation consisted of a dark shale unit underlain by a cherty limestone, possibly deposited in a marine environment of upwelling waters. However, examination of the out crop revealed no phosphate in the shale unit. The chert is secondary in origin as shown by its texture and structure. The limestone is in part colitic and contains corals. This alongwith the limited extent suggests that the dark shale was deposited in a restricted marine environment not favourable for the occurrence of phospnate rock'' (Sheldon 1966).

Other rock units of Baluchistan province which need a thorough examination as regards their phosphate content are the Zidi formation

and Paleocene Section near Zidi in Shirinab. Triassic section of Zhob District.

As regards the Foreland basin of Sind, a thorough phosphate investigational programme should be launched to check the extension of the Paleozoic phosphorite deposits of Birmania formation of Rajasthan India, under the desert sands or the Bahawalpur, Khokhrapar and Nagar Parker areas.

The recently discovered pelletal marine phosphorite lenticles in the basal Paleocene Patala Shale of the Salt Range is encouraging. A thorough search of the Eastern Salt Range may therefore be taken up on a priority basis.

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APPENDIX - 1.

COORDINATES OF PHOSPHATE OCCURENCES IN PAKISTAN

S. No.	Locality	Formation of Lithology	Age	P_2O_5 %	Lat. North	Long. East
1	2	3	4	5	6	7
1.	E. of Pabni Chauki.	Shale of Jakkhar Group.	Paleo-cene	5-15	25°16'20"	66°57'00"
2.	S. of Pabni Chauki.	—do—	—do—	5-12	25°14'00"	66°56'40"
3.	S. of Naka Levy Post	—do—	—do—	5-15	25°28'30"	67°02'00"
4.	W. of Mughal Kot	Sember Formation black Shale.	Eocene	5	31°26'30"	70°02'30"
5.	Karim Kach Khwar (E. of Kurgali).	Mughal Kot formation nodules in Shale.	Creta-ceous	5	31°33'15"	69°53'00"
6.	S. of Domanda Post.	Domanda Shale member with Oysters Shale.	Eocene	5	31°33'15"	70°11'30"
7.	—do—	Drazinda Shale member nodules in Shale.	—do—	5	31°31'15"	70°10'30"
8.	—do—	Habib Rahi lime-stone member lime-stone and Chert.	—do—	5	—do—	—do—
9.	N. of Baska	—do—	—do—	5	31°29'30"	70°08'30"
10.	Zam Tower.	—do—	—do—	5	31°44'30"	70°12'00"
11.	Zinda Pir.	Dunghan formation glauconitic sand-stone and limestone	Paleo-cene	5	30°24'15"	70°28'15"
12.	Rakhi Nala.	Ghazij Shale.	Eocene	5-20	29°57'45"	70°05'30"

S. No.	Locality	Formation of Lithology	Age	P_2O_5 %	Lat. North	Long. East
1	2	3	4	5	6	7
13.	W. of Dandot.	Patala formation coal with gypsiferous and carbonaceous shale.	Paleocene	25	32°39'15"	72°56'20"
14.	S. of Dandot.	—do—	—do—	10	32°39'10"	72°57'35"
15.	Arara.	—do —	—do—	5-10	32°32'30"	72°22'30"
16.	Katha Colliery.	—do—	—do—	5-10	32°35'15"	72°28'45"
17.	Nammal Gorge.	—do—	—do—	5	32°39'50"	71°48'00"
18.	N. of Kohat.	Chichali Formation Glauconitic, sand, shale, phosphate, nodule.	Cretaceous	5	33°37'50"	71°27'45"
19.	Wuch Khwar	—do—	—do—	15-25	33°46'00"	72°02'45"
20.	S. of Fort Lockhart.	Chichali Formation Glauconitic sandstone, siltstone and shale,	—do—	5	33°32'10"	70°56'45"
21.	N, of Darasmand.	(Chichali Form.) Glauconitic sandstone, siltstone, phosphate nodules.	—do—	5-15	33°26'45"	70°39'30"
22.	Gali Jagir.	Dolomite, Shale and Chert (Badhrar beds),	Eocene	15-30	33°26'	72°37'45" (Rapid field tests).
23.	Chor Gali.	,,	—do—	10-20	33°26'30"	72°41" (Rapid field tests).
24.	Fatehjang.	Early Murree Sandstone Shales and Grit.	Miocene	10-20	33°34'	72°38'30" (Rapid field tests).
25.	Kakul.	Cherty Dolomite Abbottabad Formation.	Devonian ?	20-35	34°12'15"	73°17'00"

S. No.	Locality	Formation of Lithology	Age	P_2O_5 %	Lat. North	Long. East
1	2	3	4	5	6	7
26.	Mirpur.	—do—	—do—	10-20	34°12′30″	73°00′22″
27.	Galdanian.	—do—	—do—	25	34°32′	73°19′08″
28.	Lagarban.	—do—	—do—	20-30	34°18′15″	73°19′30″
29.	Dabban Gali	—do—	—do—	20-30	34°19′45″	73°21′23″
30.	Sobrah Gali	—do—	—do—	5-10	34°10′07″	72°09′00″
31.	Dolala.	—do—	—do—	10-25	34°21′20″	73°23′30″
32.	Mohamda Gali.	—do—	—do—	10-15	34°04′37″	72°10′15″
33.	Balakot.	—do—	—do—	5	34°33′15″	73°20′15″

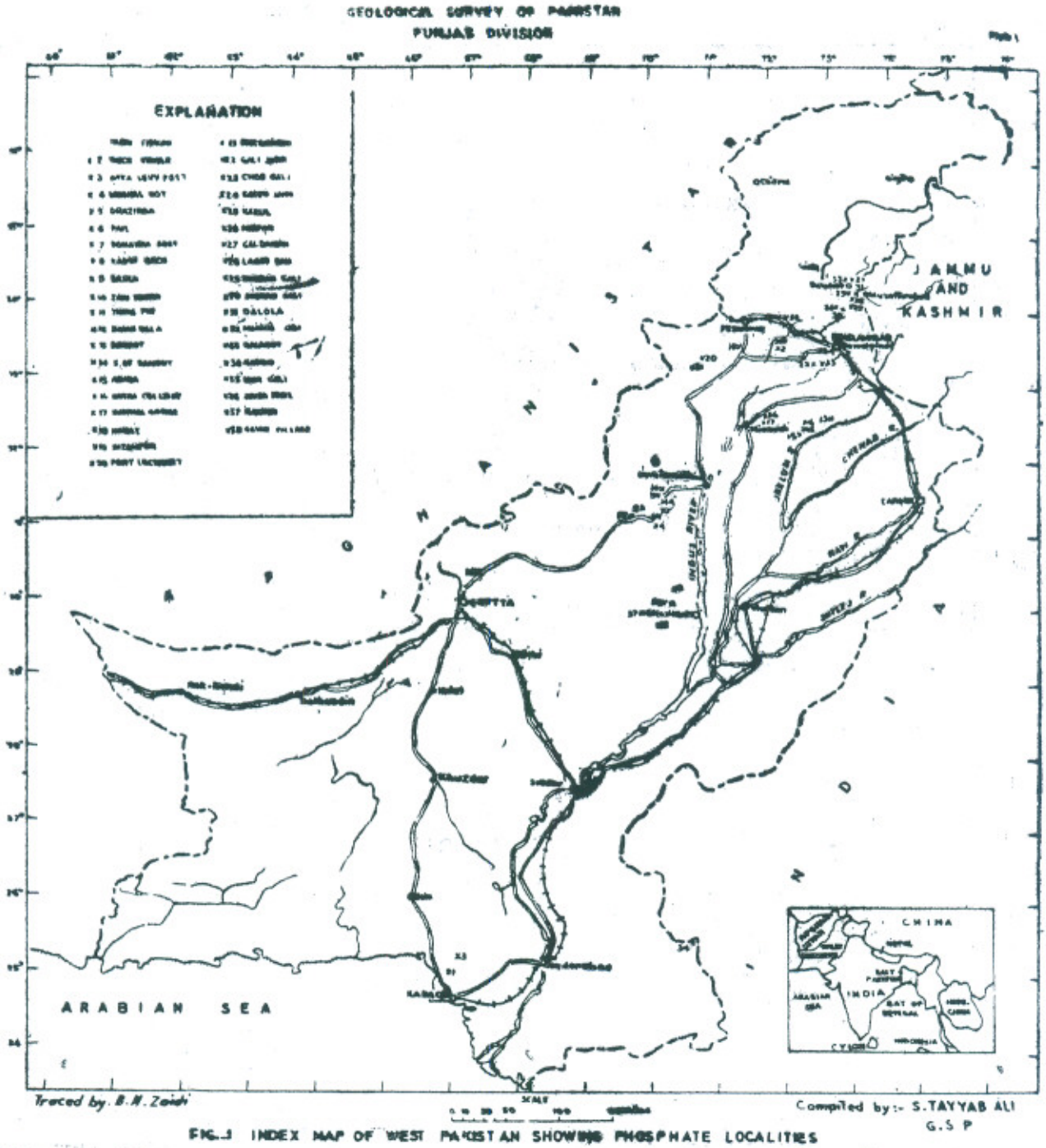
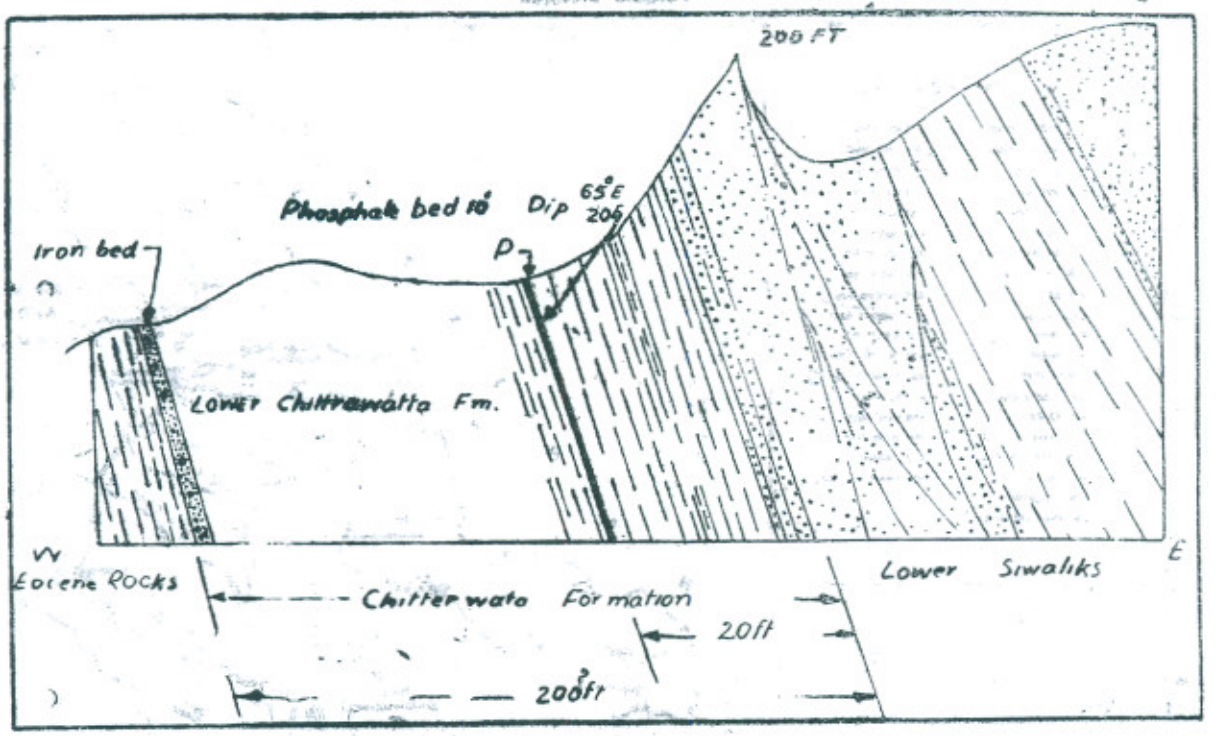
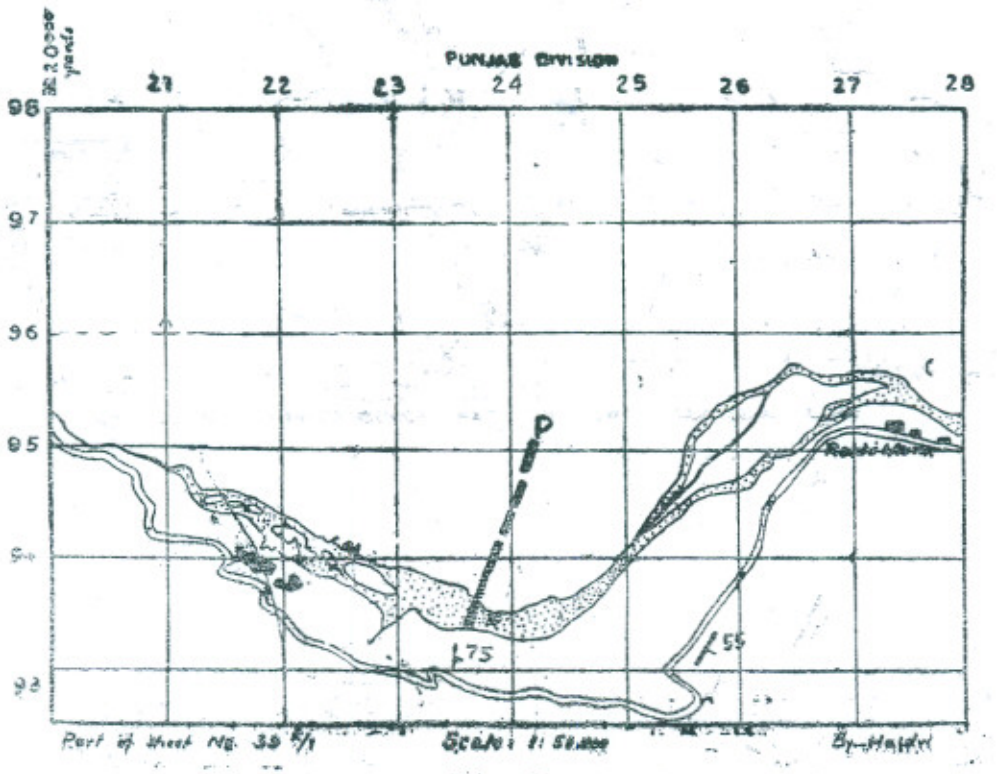


FIG. 1 INDEX MAP OF WEST PAKISTAN SHOWING PHOSPHATE LOCALITIES

D.O No 29


200 FT
Phosphate bed 10'
Dip 65° E 20°
Iron bed
P
Lower Chittrawatta Fm.
W
Eocene Rocks
Chittrawata Formation
Lower Siwaliks
E
20ft
200ft


PUNJAB Division
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96
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175
155
Part of Sheet No. 39 F/1
Scale: 1: 50,000

Fig. 2.

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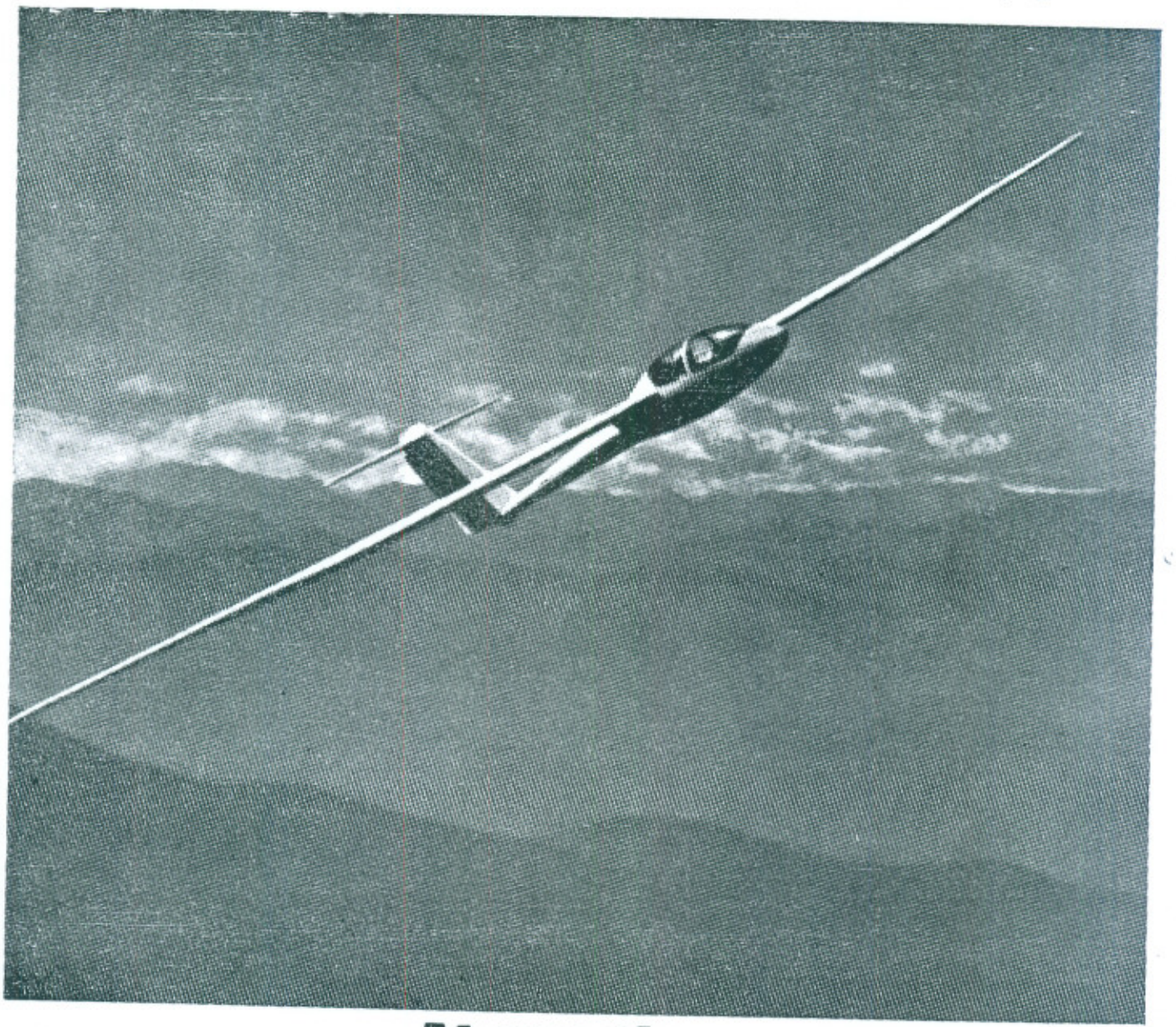

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