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Comments on critisism from R.B.Elliot, and some explorations evaluations

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Sammendrag

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Denne har vi 2 eksemplarer av

BV 419

Elkem a/s
Engineering Division

TO: Thor L. Sverdrup, Chairman of K/S A/S Fenco.

FROM: C.W. Carstens

DATE: 20th of January 1983

SUBJECT: COMMENTS ON CRITICISM FROM R.B. ELLIS AND SOME EXPLORATIONS EVALUATIONS

(Summary on page 8)

Basically it is positive to get critical feed back on reports. The comments from geophysicist R.B. Ellis are rather comprehensive and critical both with respect to the interpretation and to the used techniques. Unfortunately he has not thrown much light on alternative interpretation and more useful methods, and in that way he does not attemp to improve the exploration.

I shall admit that some results may not be documented well enough and therefore could lead to misunderstandments. However the majority of his comments are showing disagreements of principles which are assumed to be important for further progress in exploration.

I have got support from the Sydvaranger geophysicist Ø. Logn. He has also thrown light upon geophysical possibilities which we have not been too concerned about.

Getting to the point, I will try to describe the most important discrepancies and to improve my arguments.

1. Mr. Ellis says," Any statement regarding the continuity of the mineralizations between intercepts in ajacent drillholes based on used geophysical techniques are unfounded because of the lack of any depth informations."

   Most of the drilling in Tufte havna has been done on the basis of the geophysics and mineralizations have been intersected in the majority of drillholes.

   From a pure geophysical point of view most of the shallow mineralizations can be traced up to the surface by calculating and evaluations of magnetic fields from sipmle geometric models using measured suspectibility informations.

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Our previous detail magnetic isomap in Tufte are revealing a banded content of magnetite more than diffuse variability of that mineral. A general trend is an isomap indicating a strike direction which is in accordance with geological structure informations. When making connections in the third dimension of zones of similar magnetite content and similar radiometric response we get structure directions diping steeply torwards west which are in good agreements with structure informations from surface and the dip direction of geological zones from the drillholes. The above mentioned agreements between geological and geophysical structures on certain areas must be a good indication that the used geophysical methods are suitable in delineating geological structures in 3 dimensions.

2. Mr. Ellis is worried about that a correlation of low magnetite and high radiometric response is not unique to the mineralized areas. He thinks that is most important from an exploration standpoint.

I must of course agree with Mr. Ellis that a correlation of low magnetite and high radiometric response is not unique to the mineralized zones. It should however be well known for explorationists that the search for mineralizations are by its nature a fuction of complex probabilities, and consequently unique correlations are seldom found.

Within a drilled thickness of about 8 m the findings of drillhole 1 and 3 are grading to about 2,7% Nb_2O_5 and 12% Nb_2O_5. The mineralizations are associated with lamprophyre and are certainly economic interesting. Compared with other zones the petrophysical pattern of low magnetite and high radiometric response is most distinct with respect to the economical findings.

My conclusion is that magnetic and radiometric methods must be useful methods in delineating structures which may be favourable for the occurce of an orebody.

3. Like other Union Mineral explorationists Mr. Ellis is especially sceptical to the usefulness of radioactive investigation methods.

The argument against the method is based on overburden effects and influence of groundwater and overburden transport.

With respect to further arguments favouring the method I will refer to the geophysicist Ø. Logn who has recountoured the radiometric map detailly. He gets radioactive haloeffects in 3 areas having an outline of flattened elipses which reweal a similar orientation. Haloeffects are also observed in drillholes where it seems to be a correlation with low grade of

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Niobium mineralizations. The center of the above mentioned haloellipses are situated on a line running from Tuftehavna drilling area up to the old Holla Church area.

The old Holla Church area, giving the highest radioactive respone, is situated outside the Søvite. Some geologists have indicated that the Søvite should be given 1.priority with respect to further exploration. On the basis of Logn's radioactive haloeffects and the interesting results of drill-hole 11 just outside the Søvite complex one reasonable work-hypothesis is also to check radioactive areas outside the Søvite.

Drilling to check magnetic low and radioactive structures has already been proposed. It is assumed to be possible to improve that drilling program on the basis of Logn's halo-studies.

At last I will mention that the radiometric results played a central role in finding the Niobec niobium mine in Canada.

4. Mr. Ellis thinks my recommentation for further geophysical investigations are very comprehensive, and it is unclear to him how additional surveys will increase the probability of locating mineralizations.

By further exploration we should be concerned with the probability of finding economic mineralization by drilling a minimum of wild cats holes. The geologists should try to gain a more thourough understanding of mineral genesis to define models at which exploration efforts can be targeted. Due to the great lack of outcrops such modeling may be difficult and therefore further geophysical explorations should be given priority.

If we accept a work hypothesis of focusing on structures revealing low magnetic and high radiometric response a great deal of such structures will probably not represent interesting mineralizations. By using additional geophysical tecjniques it should be possible to classify the structures mentioned above and select the most promising ones as drilling targets.

GRAVITY INVESTIGATIONS

Density investigations are made on 6 lamprophyre and 23 Søvite samples and the results are respectively 3,14 g/cm^3 and 2,84 g/cm^3.

The lamprophyre is heavier than the Søvite having a density contrast of 0,3 g/cm^3, and the consequence is that gravimetric investigations should be considered to delineate lamprophyres.

Beeing influenced by geophysicist Ø. Logn I have focused more on the considerable gravity anomaly of the Fen-complex. May be the gravimetric anomaly explains why the geologists have located a very minimum of lamprophyre outcrops. The average density of known rock types cannot explain the anomaly. Compared with the surrounding gneiss the density contrast of lamprophyre is about twice that of known carbonatite rocks.

The gravemitric anomaly may be explained by a heavy pipe like or cone-shaped mass having a density equivalent to that of the lamprophyre. The thinner the carbonatite-overburden is assumed to be better is the fit between calculated and measures anomaly. (Ramberg 1972).

Even if the density of rocks like domkjernite, vipetoite and Melteigitt are rather close to that of lamprophyre. The gravimetric anomaly opens interesting perspectives of locating a rather big mass of lamprophyre, which may occur at some depth.

Ramberg's investigations are of a more regional character, and the level corrections are not too exactly beeing based on maps. To define a drilling target the resolution should be improved. Consequently more gravity investigations should be followed up.

Electric - electromagnetic soundings

Prior to further gravimetric investigations electric soundings should be carried out to delineate the soil overburden thickness which is of importance to interpretate gravity anomalies and also radiometric anomalies. As mentioned in the geophysical report Logn has carried out electric soundings in 1954 in the Northern Tufte area, and good results were obtained to delineate the overburden thickness.

Due to overburden soil it is difficult to map tectonical structures. It is assumed that it is important to know such structures to build up geological models at which exploration efforts can be focused on. Electric soundings or alternatively VLF soundings should be useful in delineating faultzones.

Concerning the already done VLF Investigations it is understandable that Mr. Ellis had problems in seeing the faultzones on the basis of the materials presented in the geophysical report. The report presents the VLF-resistivity results, while the interpretations of the faultzones are mostly based on the dip angle investigations. Unfortunately the dip angle results are not presented in the report.

Seismics

Mr. Ellis says that seismics are not suited for vertical contact geology. I will not stress that method and give it any high priority, but we have got a report on the subject " Geological interpretation of seismic soundings at the Sokli Carbonatite Complex, Northern Finland ", and that report is showing that good results are obtained by seismic soundings on the ground as well as drillhole- seismic soundings.

The acoustic properties of rocks is prinsipally a result of density contrasts and consequently the method may be applicabel both to delineate the extensions of the Søvite towards the depth and to indicate potentials of lamprophyre within the Søvite.

5. Mr. Ellis is quite correct when he is assuming that my economical considerations are premature.

Feeling that it must be useful and valuable for exploratio-nists to have an idea of what grades and tonnages is re-quired to start mining in Fen. I will try to give a rough evaluation of that subject. The objective is also to get feed back from Union that already are involved in mining of niobium.

Some information of known deposites is listed up:

Deposite	reserves mill. tons	grade Nb_2O_5	recovery %	grade concentr. Nb_2O_5	tons of concentrate /year
Araxa (Brazil)	460	2,5 - 3%	70	60	24.500
Niobec (Canada)	40	0,7%	65 - 70	60	2.800
OKA (Canada-closed)	24	0,45%			
Søve (Norway-closed)		0,3%	55		

70% of the world's niobium reserves are located in Brazil where Araxa is the biggest mine. That mine is producing at a very high mining cut off grade amounting to 2,5% Nb_2O_5, and it has pressed down the niobium prices.

The following prices are indicated:

Pyroclore concentrate	from Canada	7 $ / kg Nb_2O_5
Columbitt	" Zif US Hafen	6,5$ / kg Nb_2O_5

The value of ta-rich columbitt concentrate is about twice the value of pyroclore concentrate. Minerals belonging to the columbitt group are identified within the lamprophyre but it is uncertain what kind of concentrate that may be produced from a mineralized Fen-lamprophyre.

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It is worth to notice that the distance from Fen to Norsk Hydro's fertilizer-factory is not more than about 30 km. Today Hydro is paying about NOK 500/ ton for phosphate-concentrate. Consequently Apatite may be a valuable by product in Fen. Based on what Hydro is paying for the Kola-apatite their own apatite deposite (Kodalen) is very closed to be mineable. The grade in Kodalen is about 8,1% P_2O_5. According to Hydro the minimum production grade by open pit mining should be about 10% P_2O_5 to start apatite.

In Fen area it is assumed to be important that a potential future mining-operation must be carried out by a minimum of disturbance by landowners and the population. In that way an underground mining operation will probably be best suited.

The production capacity must depend on accessible tonnage and the market situation. Even if we are far from having delineated any ore-body, we do have results that indicate that one may be found. 4 - 5 millions tons may be a reasonable figure. Today the market situation is not too good and to be somewhat moderate I think a production rate amounting to 200.000 - 300.000 tons of crude ore may be realistic.

In the following I have tried to indicate minimums of ore values required at different pay back times.

ore production	min. ore value 5 years pay back	min. ore value 10 years pay back
200.000 t	NOK 300 / ton	NOK 190 / ton
300.000 t	NOK 260 / "	NOK 160 / "

With respect to 5 years pay back times the depreciations, interests charge and profits are amounting to about 55% of the minimum ore value. Mining and oredressing costs are amounting to 25% and 12% respectively .

To indicate the value of insitu mineralizations recoveries must be indicated. To be careful 50% are indicated for making a niobium concentrate and 80% for concentrating apatite. Truck transport for apatite concentrate to Hydro is estimated to be about NOK 1/ km.

1% Nb_2O_5	~ NOK 240/ton
1% P_2O_5	~ NOK 10/ "

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If my figures are correct the grade required to think mining must be in the order of 0,8% Nb_2O_5 and 6% P_2O_5.

Finally the values of some findings from Fen are indicated:

Drillhole	thickness	% Nb_2O_5	% P_2O_5	"Value" NOK/ton
average 1 and 3	8	2,7	12	780
average 7 and 8	2 3	1,4	14,5	240
12	3,5	0,4	10,5	190
11	6	0,5	8,9	210

Especially the lamprophyre structure (drillhole 1,3,7,8,12) are showing grades which should be "mineable". Rather interesting grades do also occur within the Søvite and in the Raudhaugite (drillhole 11).

Unfortunately the extensions of the mineralized zones are too small and we have not found any big "elephant" yet. However more drilling in the depth direction should be considered.

From a geophysical point of view especially the considerable gravimetric Fen-anomaly opens interesting perspectives of finding a big lamprophyre mass.

To produce 200.000 - 300.000 tons crude ore per year it is assumed that we must have a minimum ore tonnage of 4-5 millions of tons. The geophysical grid system and the space of drilling must depend on the geometric form of that hypothetic ore.

If we assume that an orebody may occur as a mass beeing cylinder formed, then I think a grid system of 25m x 5-10m may be appropriate concerning detail magnetic, radiometric and gravity investigations in certain areas.

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SUMMARY

My reply and comments to the criticism of Mr. Ellis certainly got more extensive than I originally had ment to do. However, it has been written in a period where it is uncertain whether it will be any progress in the Fenco-Work, and I therefore felt a need for argueing for a continuation of that work.

Unfortunately I cannot see that Mr. Ellis has made attempt to give alternative interpretation and to propose alternatives of methods that might improve explorations in Fen. Being somewhat influenced by geophysicist Ø.Logn a summary is made:

1. Disagreeing with Mr. Ellis I think we have to accept that it is an interesting correction of petrophysical parameters and mineralisations of niobium and apatite. Consequently it is worth to check up radiometric haloeffects both within and outside the Søvite. Magnetic and radiometric detail investigation should be followed up systematically.

2. The lamprophyre in which the most interesting grades occur is the heaviest rock type so far located in Fen area. The considerable gravimetric anomaly in Fen may be explained by masses having the density to that of the lamprophyre. consequently more detailed gravimetric investigations should be followed up to improve the target at which drilling should be done.

3. VLF and electric soundings have turned out to be useful tools in delineating faultzones and the thickness of overburden materials. Such investigations should be followed up.

Even if the market situation (niobium) is somewhat difficult it can be good prospecting philosophy to strive to remain the exploration. The economic climate changes rapidely. Any prunning of the exploration budget at an early stage of a project may have serious impact on overall costs when the climate improves.

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