Ultra Scientist Vol. 28(3)B, 80-87 (2016). ISSN 2231-3478 (Print)
www.ultrascientist.org 2319-8052 (Online)

# Ore Mineralogical and Geochemical Characterization of Kyanite - Pyrophyllite Schist around Nawargaon-Chowa Sector of Sakoli Fold Belt, Bhandara District, Maharashtra (India)

H. S. KALE

Department of Geology, RTM Nagpur University, Nagpur-440001 (India)
E-mail:mahakal46@gmail.com

**(Acceptance Date 10th July, 2016)**

## Abstract

The Sakoli fold belt mainly comprises the supracrustal rocks of Lower to Middle Proterozoic age. These include metapelites, quartzite, basalt and rhyolite along with some intrusion of granitic and gabbroic rocks. This area is positioned at the southern margin of the Central Indian Tectonic Zone and also at northern margin of the Baster Craton. This areal extent of the CITZ is about 5000km$^2$. Nawargaon- Chowa area belongs to Sakoli Group of rocks which is structurally very complex which reflects in different phases folding, at some places it is extremely mylonitised, sheared and silicified with low to medium grade of metamorphism. In the study area the exposures of kyanite, quartzite and chlorite schist shows the strike direction NW-SE with a dip of $50^0$ to $65^0$due NE.Pyrophyllite of the study area is characterized by wide spectrum of textural varieties confirming to varying grades including refractory. The kyanite schist is pale greenish in colour, which shows medium grained texture and schistose structure with some ferruginous matrix surrounding the quartz grain. Major oxide data of kyanite and pyrophyllite samples shows that the alumina and silica is the major component. The $Al_2O_3$ percentage in pyrophyllite is ranging from 47.22 to 51.56 %.

*Key words:* Central Indian Tectonic Zone, Sakoli Fold Belt, Refractory, Baster Craton, Pyrophyllite, Kyanite

## Introduction

The Sakoli Group of rocks was first mapped by Bhattacharjee[1] and Chatterjee (1929-32) and established stratigraphic succession of Sakoli Group. B. K. Bandopadhya *et al*.[3] gave a comprehensive account on geology, structure, metamorphism and mineralization of the Sakoli fold belt. Bhoskar *et al*.[5] studied platinum Group metal in Sakoli fold belt.In few decades the work was under taken by Geological Survey of India by Bhoskar[5], Mahapatra *et al*.[8], Sarkar[9]. The supracrustal rocks of Sakoli fold belt mainly comprises of four different formations; these are Gaikhuri, Dhabetekri, Bhiwapur, and Pawni formations from oldest to youngest[3,7]. Sarkar *et al*.[10,11], Bandopadhyay *et al*.[2] have contributed on geochronological aspects in parts of the Precambrian of Central India.

*Geological Setting :*

The rocks of Sakoli Group of lower to middle Proterozoic age form triangular outcrops in parts of Nagpur, Bhandara and Chandrapur District of Maharashtra known as the "Bhandara triangle", which is formed by the three lineaments. The Sakoli basin are folded isoclinally and refolded into synclinorium. The shear zones, strike and traverse faults and masses of quartz veins are noted on a regional pattern in the entire basin. viz Nagpur, Bhandara and Gadchiroli. These supracrustal rocks are bonded in north, south and east by the basement granitic gneisses of the Amgaon Group. The Sakoli Group of rocks are highly deformed and they are formed the metamorphosed

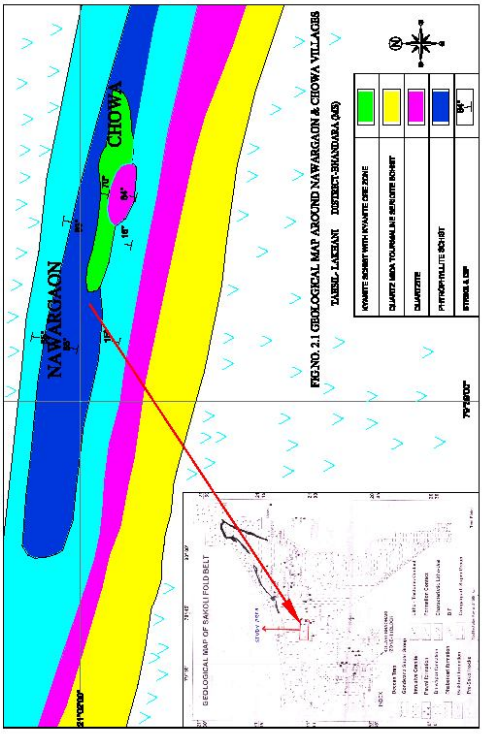


Figure 1. Geological map of Nawargaon-Chowa villages

In the study area the exposures of Kyanite and quartzite and chlorite schist and conspicuously exposed in Chowa area. The strike of these rocks as observed in the field is NW-SE with dips of 55 to 65 due NE. Because of structural disturbance opposite dips are also observed in quartzite, joints are well developed. The distribution of pyrophyllite occurrence of Navargao-Chowa indicates that their formation cannot be simply explained by their association with shear zones, but supports our suggestion for retrograde metamorphism.

*Kyanite Schist:* The quartz Kyanite rock is exposed at places over a length of about 5km from Jamgaon to Chowa village. The area is the eastern extension of Jamgaon –

Table 1. The lithostatigraphical succession of Sakoli fold belt
After Roy *et al*. (1995)

| | | |
|---|---|---|
| Gondwana Super Group | | |
| Faulted contact | | |
| Intrusive | | Quartz veins, reefs and silicified zone, Alkali feldspar granite (Purkhabori granite), Pegmatite, tourmaline granite-(Mandhal-Granite), Gabbro/Dolerite(metamorphosed |
| | Pawni Formation | Slate, Phyllite, meta-arkose, quartzite, matrix supported conglomerate |
| | Bhiwapur Formation | Mainly metapelite+chloritoid andalusite garnet staurolite with inter bands of metamorphosed acid volcanic/ tuffs, minor psammites, exhalative sediments coticule, tourmaline), Banded Garnet, Amphibolites Rock (BGA), rare basic volcanic and syngenetic base metal (Zn, Cu) mineralization. |
| | Dhabetekri Formation | Mainly metabasalts with subordinate metapelites, chert bands and meta ultramafic rock. |
| | Gaikhuri Formation | Conglomerate, gritty quartzite, meta arkose, minor phyllite (at places carbonaceous) and Banded Ferruginous Quartzite (BIF) AND BGA |
| Tectonised Zone | | |
| Pre-Sakoli | Amgaon Gneissic Complex (AGC) | Gneisses and migmatites, granitoids, amphibolites, chromite bearing meta ultramafites and Pre-Sakoli supracrustal assemblages of high grade schists including quartzite, Kyanite and sillimanite schistts, calc- silicate rocks ,marble, cordierite-gedrite-anthophyllite schists, garnet- staurolite schists etc. |

Nawargaon Kyanite deposits. Kyanite occurs in the form of veins having partings of mica and chlorite schist. Kyanite also occurs in massive form, bluish in colour and contaminated with tourmaline. The quartz – Kyanite tourmaline rock is exposed at places within the leasehold area. The length of Kyanite quartz rock bed is about 130m. Width varying from 8 to 25m. Kyanite is low to medium grade having 40 to 48%$Al_2O_3$ content.

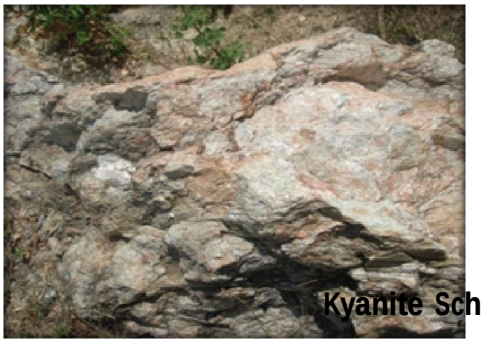


Fig. 2. Exposure kyanite schist showing good developed schistocity

*Pyrophyllite Schist :*

It is off white to buff colour, occurs in association with kyanite in lensoid form. At places it is contaminated with tourmaline. It is medium grained shows good schistocity and foliation, greasy feel. It is not very conspicuous in its occurrence, except as associated as mineral (Fig 2.3 NP-7).

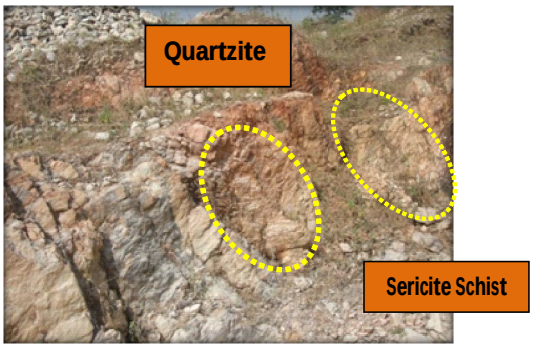


Fig. 3. Exposures of Quartzite and Sericite Schist

*Petrography :*

*Kyanite Schist :*

It is pale greenish in colour. It is medium grained rock shows foliation and schistocity. It shows Lepidoblastic texture i.e. parallel orientation of minerals. The specific gravity is high, shows good cleavage. It shows medium grained texture and schistose structure. Some ferruginous matrix is seen surrounding quartz grains. Minerlogically it is composed of Kyanite which is in bladed form, blue colour, medium grain Muscovite shows platy form, is colorless with perfect cleavage and low relief under PPL. Under crossed nicols it displays high order polarization colour (pink) and parallel extinction under crossed nicols.Quartz:-shows euhedral to subhedral form, is colorless with low relief and devoid of cleavage under PPL. Under crossed nicols, it exhibits 1 order (grey) polarization colour. (Fig. 5, 1 and 2)

*Pyrophyllite Mica schist :*

It is white in colour, shows good foliation and schistocity. It is fine grain with low specific gravity, greasy feel. Concentration of mica is lesser than Pyrophyllite, it shows dull luster. It shows fine grained texture as well as medium grained texture. Minerlogically it is composed of PyrophylliteIt is colorless under plane polarized light, shows elongated from, one directional cleavage and moderate relief. Under crossed nicols it is anisotropic and shows almost parallel extinction, higher II$^{nd}$ and lower I$^{st}$ order colors. Pyrophyllite shows less distinct cleavage than muscovite. Muscoviteshows platy form is colorless with perfect cleavage and low relief under ppl. Under crossed nicols it displays II$^{nd}$ order polarization colour (pink) and parallel extinction under crossed nicols. Quartz shows euhedral to subhedral form, is colorless with low relief and devoid of cleavage under PPL. Under crossed nicols, it exhibits I$^{st}$ order (grey) polarization colour (Fig. 6, 6 and 7).

*Pyrophyllite Tourmaline schist :*

In this black Tourmaline schist sample the greenish colour Pyrophyllite vein is intruded. It is fine grain, Pyrophyllite is contaminated with Tourmaline. Minerlogically it is composed ofPyrophyllite which is colorless under plane polarized light, shows elongated from, one directional cleavage and moderate relief. Under crossed nicols it is anisotropic and shows almost parallel extinction, higher II$^{nd}$ and lower

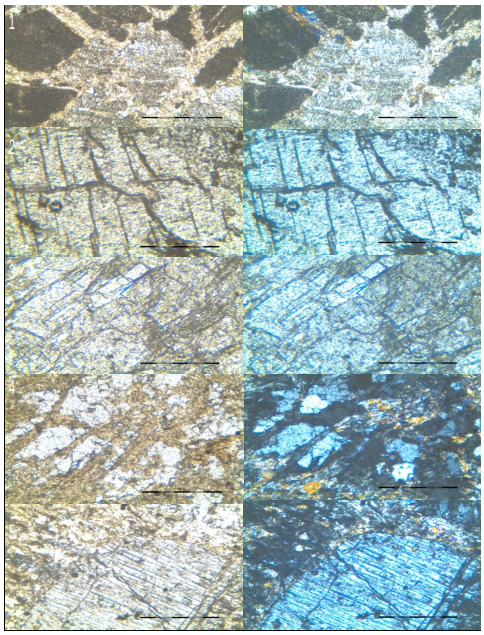

Fig. 5. Microphotograph of Kyanite and Pyrophyllite Schist

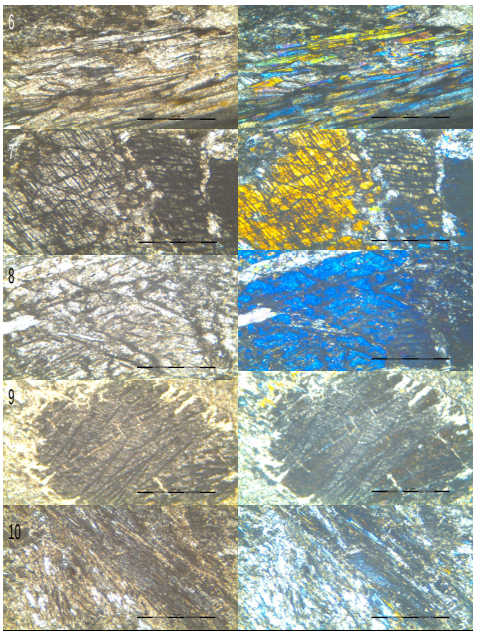

Fig. 6. Microphotograph of Kyanite and Pyrophyllite Schist

I$^{st}$ order colors. Pyrophyllite shows less distinct cleavage than muscoviteshows almost parallel extinction, Pyrophyllite shows less distinct cleavage than muscovite. Quartz shows euhedral to subhedral form, is colorless with low relief and devoid of cleavage under PPL. Under crossed nicols, it exhibits I$^{st}$ order (grey) polarization colour.In some samples pyrophyllite replaces some kyanite (Fig. 5,2). In thin section, Kyanite is first replaced around its edges and along cleavages (Fig.5, 3), with advancing replacement, kyanite becomes more ragged and pyrophyllite better crystallized (Fig.5, 4). Initially pyrophyllite occurs in small flakes, but with advanced replacement, it assumes larger form that isin optical orientation (Fig.5, 5).

*Analytical techniques :*

Representative sample was collected from entire samples and prepared chips of one to five mm by coning and quartering method. Finally 200 mesh size powder was prepared by pulverizor. Sample pallets' were prepared for analysis by X- Ray florescence spectrometry using baking of Boric Acid and processing it at 25tonnes of pressure. A hydraulic pressure was used to prepare the pallets for XRF analysis to determine major elements.

Whole rock geochemical analysis for the major element were determined by florescence spectrometry (XRF) using Philips MAGIX PRO (model PW 2440) fully automatic micro processor controlled at Indian Bureau of Mines.

Table 2. Major oxide (Wt %) of Kyanite and Pyrophyllite schists

| Major oxide% | CK-1 | CK-2 | CK-3 | CK-5 | NK-6 | NK-7 | NP-8 | NP-9 | CP-10 | CP-11 |
|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 42.21 | 44.88 | 51.86 | 42.71 | 48.71 | 43.26 | 45.22 | 51.56 | 46.90 | 48.64 |
| $Al_2O_3$ | 48.92 | 45.18 | 32.40 | 40.61 | 34.75 | 42.70 | 39.13 | 32.23 | 36.08 | 34.48 |
| $Fe_2O_3$ | 0.71 | 0.43 | 1.19 | 1.48 | 1.31 | 0.27 | 0.61 | 1.55 | 3.32 | 1.29 |
| $TiO_2$ | 0.53 | 0.49 | 0.52 | 0.76 | 0.50 | 0.26 | 0.37 | 0.46 | 0.49 | 0.15 |
| $Cr_2O_3$ | 0.05 | 0.04 | 0.05 | 0.07 | 0.05 | 0.02 | 0.03 | 0.04 | 0.07 | 0.02 |
| $P_2O_5$ | 0.36 | 0.15 | 0.26 | 0.12 | 0.53 | 0.17 | 0.25 | 0.12 | 0.06 | 0.27 |
| CaO | 0.60 | 0.79 | 0.33 | 0.24 | 0.58 | 2.99 | 2.12 | 0.42 | 0.76 | 0.52 |
| MgO | 1.16 | 0.47 | 5.60 | 6.30 | 6.33 | 0.16 | 0.75 | 4.33 | 2.05 | 0.65 |
| $Na_2O$ | 1.83 | 2.38 | 0.64 | 0.93 | 0.62 | 3.62 | 5.42 | 1.90 | 3.36 | 2.05 |
| $K_2O$ | 1.93 | 2.53 | 2.89 | 2.48 | 2.31 | 1.61 | 1.78 | 3.50 | 3.51 | 7.15 |
| LOI | 1.33 | 2.32 | 3.30 | 3.26 | 3.32 | 4.54 | 3.92 | 3.22 | 2.72 | 4.07 |
| Total | 99.63 | 99.70 | 99.04 | 98.96 | 99.01 | 99.19 | 98.57 | 99.33 | 99.32 | 99.29 |

*Major Oxide Chemistry :*

Major oxides data of four Pyrophyllite schist samples and six kyanite schist samples given in the table 2. Chemical data of Pyrophyllite schist observed that alumina and silica is the major constituent. $Al_2O_3$ in pyrophyllite schist ranges from 45.22%-51.56% (Fig.7.A), illustrate negative co-relation between $SiO_2$ Vs $Al_2O_3$ and in the kyanite schist ranges from 32.40-48.92% bivarent diagram $SiO_2$ Vs$Al_2O_3$ shows negative co-relation like as pyrophyllite schist (Fig.7, A). In these rocks silica content varies from 42.21-51.86% where as$Al_2O_3$ varies from 32.23-48.92%. Presence of relatively quartz in Pyrophyllite schist mineralized zone is evidenced for high silica activity in fluid phase during pyrophyllitisation (Sykes and Moody *et. al.* 2012). The concentration of $Al_2O_3$ in the kyanite schist comparatively more than pyrophyllite schist but reverse with respect to $SiO_2$. (Fig.7,H) Pyrophyllite schist indicates more systematic sodium along with silica from the parent rock. $Na_2O$ in the Pyrophyllite schist ranges from 1.9-5.42% and sodium oxide content in the kyanite schist ranges from 0.6-3.62% the $SiO_2$Vs $Na_2O$ shows more or less same behavior.(Fig.7, I) shows linear to slightly positive behavior with $SiO_2$ Vs $K_2O$ in the Pyrophyllite as well as kyanite schist content of $K_2O$ in the pyrophyllite is 1.78-7.15% where as in the kyanite is 1.61-2.89%. The approximate percentage of CaO in the Kyanite is 0.92% while 0.96 in the pyrophyllite schist. It shows almost identical behavior and their role of removal from parent rock is almost same in order (Fig.7 F). The concentration of $P_2O_5$ in Kyanite schist varies from 0.12-0.53% and it shows linear to slightly positive correlation with silica where as linear to negative in the Pyrophyllite schist. The approximate concen-

tration of $P_2O_5$ in the pyrophyllite schist is 0.18% content of $P_2O_5$ is more in the kyanite schist than pyrophyllite schist. The behavior of the $TiO_2$ in Kyanite as well as pyrophyllite schist is almost same and Fig.7, C show linear behavior with the $SiO_2$ $TiO_2$ varies from 0.26-0.76% in the kyanite schist as 0.15-0.49% in both rocks is almost same. Harker diagram of Kyanite and as pyrophyllite schist between MgO vs $SiO_2$ shows strong co-relation. The average content of MgO in the kyanite schist is 3.3% and it varies from 0.16-6.33%. The concentration MgO in the pyrophyllite schist is 0.65-4.33%.

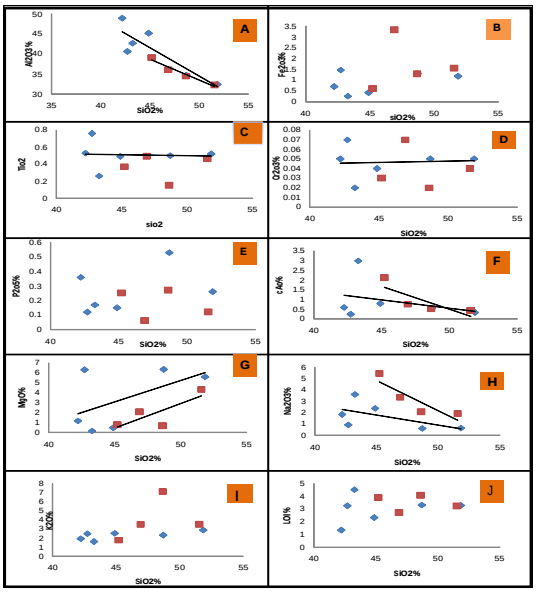


Fig. 7. Variation plots, $SiO_2$ versus major oxides

## Conclusion

On the basis of major chemical composition of rock of study area conclude that the original metasediment and is found only in the rock with high Si and Al. Pyrophyllite of study area is characterized by a spectrum of textural varieties confirming to vary grades including and refractory. From the totality of mode of occurrence, mineral assemblages of the pyrophyllite deposits of mad. Major oxide data of from five Kyanite samples and five pyrophyllite samples show that and alumina and silica is the major component. $Al_2O_3$ in Pyrophyllite ranges from 47.22% to 51.56%. The bivarent plot of $SiO_2$ vs. $Al_2O_3$ depicts the negative correlation. $Na_2O$ in the Pyrophyllite Schist ranges from 1.9 to 5.42% and in Kyanite schist it ranges from 0.6 to 3.62%. The bivariate plot of $SiO_2$ vs. $Na_2O$ shows similar trend. The bivariate plot $SiO_2$/ $K_2O$ shows slightly positive behavior. The approximate percentage of CaO in the kyanite is 0.92 % while 0.96 % in the pyrophyllite schist. In the bivariate plotting it shows identical behavior and their role of removal from parent rock is almost same in order. The concentration of $P_2O_5$ in kyanite schist ranging from 0.12% to 0.53%. In bivariate plot $SiO_2/P_2O_5$ indicate the linear to slightly positive correlation. $TiO_2$, MgO also shows the linear behavior.

## References

1. Bhattacharjee, D.S., General report section of *geological survey of India*, Report Vol. *71*, Part -1, pp. 60-70 (1937).
2. Bandyopadhyay, B.K., Bhoskar, K.G., Ramchandra, H.M., Roy, Abhinaba, Khadse, V.K., Mohan, M., Sreeramchandra Rao, Ray, Barman, Bishui, P.K., and Gupta, N., Recent Geochronological Studies in the parts of the Precambrian of Central India.

*Geol. Surv. India, Special Pub. 28*, 199-210 (1990).
3. Bandopadhyay, B.K, Roy Abhinaba and Huin, A.K., Structure and Tectonics of a part of the Central Indian Shield. *Mem. Geol. Soc. India, 31*, 433-467 (1995).
4. Bhoskar, K.G., Saha, A.K. and Mahapatra, K. G., Targeting for platinum group metals in hydrothermal vein set-up: A case history from Sakoli fold belt, Maharashtra. Gond. *Geol. Mag. Spl*. V. *7*. Pp. 421-429 (2003).
5. Bhoskar, K.G., Banded Iron Formations of the Sakoli Group and related Metallogeny. *Geol. Surv. India, Spl. Publ.,* V. *28*, pp. 658-675 (1990).
6. Mahapatra, K.C., Saha, A. K., Bhoskar, K.G. and Gupta, A., Platinum incidences from auriferous quartz veins of Bhimsen Killa Pahar area, Sakoli Fold belt, Bhandara district, Maharashtra. *Geol. Surv. India, Spl. Publ.,* V. *58*, pp. 475-463 (2001).
7. Roy Abhinaba, Charles Mony, P.C.D. and Saha, A.K., Geology of the Sakoli Fold Belt, Nagpur, Bhandara and Gadchiroli districts, Maharashtra, Central India. Unpub. Rep. for the f.S. 1988-1994 (1994).
8. Saha, A. K., Mahapatra, K.C., Shom, S. and Bhoskar K.G., A first report of incidences of platinum in the auriferous quartz veins from Sakoli Fold belt, Maharashtra. *Jour. Geol. Soc.* India, V. %7, pp. 451-454 (2001).
9. Sarkar, S.N., Gerling, E.K., Polkanov, A.A. and Chukrov, F.V., Precambrian geochemistry of Nagpur- Bhandara-Durg, India, *Geol., Mag., 104*, 525-549 (1967).
10. Sarkar, S.N., Gopalan K.and Trivedi, J.R., New Data on the geochronology of the Precambrian of Nagpur- Bhandara-Durg, India, *J. earth. Sci., 8*, 131-151 (1981).
11. Sarkar, S.N, Trivedi, J.R. and Gopalan K., Rb-Sr whole-rock and mineral isochron age of the Tirodi Gneiss, Sausar Group, Bhandara District Maharashtra. *J. Geol. Soc.* India, *27*, 30-37 (1986).
12. Sykes, M.L. and Moody, J.B., Pyrophyllite and metamorphism in the Carolina slate belt. *American Mineralogist*, Vol. *63*, pp. 96-108 (1978).