SPONTANEOUS COMBUSTION IN COALS - A PANACEA by P Behera

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(1)

S.C. Nayak, MA/52, G G P Colony, P O Rasulgarh, Bhubaneswar - 751 010, comments

The author has attempted to find out a universal method of classifying Indian coals into highly-, moderately- and least-prone to spontaneous combustion from experimental values of volatile matter in coal The following points need to be clarified before applying the so-called universal model

1 The author has used the data of Ib-valley, Talcher and Raniganj coals (Tables 3 and 4) out of which those of Ib-valley are author's own data and others have been taken from other published literatures (p 160, lines 16-17) However, the relevant references have not been indicated

2 In Table 1, a parting of 90-120 m thickness has been shown below the Ib seam (Karharbari Formation) Generally strata between seams are termed as partings When underlying Talchirs are devoid of coal, should the strata between Talchir Formation and Ib-seam be designated as parting?

3 In text (p 160, left column), Table 3 comes after Table 1, ignoring Table 2 The Table 2 contains the concluding remarks of the paper, which should come towards the end Is it not a case of organizational error?

4 The author has related the volatile matter of Ib-valley and Talcher coals with crossing point temperature values (p 160, right column and Table 4) Neither the mean values nor any supporting graph/figure/ argument is given to substantiate the statement

5 At p 160 (right column), the author has given ranges of VM values for Ib-valley, Talcher and Raniganj coals, which differ substantially from those given in Tables 3 and 4 There is no consistency of data At the same place the author states that the upper limit of VM of Raniganj coals studied by Chandra and Prasad (1989) was increased from 45% to 64% in the light of data of Talcher and Ib-valley coals Is it justified to manipulate the experimental values of one coalfield in the light of findings from other areas?

6 The framework of Fig 2 seems to be adopted from some published work on which data of Ib valley and Talcher coals have been plotted The source is not indicated The limits of Ib and Talcher coals are shown by a single dotted line, which does not convey any meaning

7 As evidenced from Table 3 and Figs 4, 6 and 8, the author has analysed only 5 coal samples from Rampur seam, but in Fig 2 there are 12 solid triangles representing Rampur seam In case of Talchir coals three samples have VM greater than 55, but only two points have been shown beyond 55 marks in Fig 2 There are 8 data of Talcher seam-I, but Figs 3,5, and 7 indicate 9 plots of the same In Fig 9, the plots of Talcher seams I and II seem to be interchanged If this is true, there are 9 plots for seam-I also How are these possible?

8 In p 163 (lines 4-7), the author is reluctant to accept CPT as a measure the degree of spontaneous combustion of coal In the succeeding p 164, lines 12-14 (from the data of Table 4) the author indicates the existence of definite relationship between VM (calculated) and C V (calculated) with CPT (which is not substantiated) and concludes that these parameters may be used for determining the degree of spontaneous combustibility of coal These statements contradict each other Further, in Table 4 the values of VM (experimental), VM (calculated) and CPT are given in ranges whereas the values of C V (calculated) are given in absolute terms This indicates inconsistency of data presentation

9 At p 164 and Table 2, the author arbitrarily classified the coals into highly-, moderately- and least prone to spontaneous combustion on the basis of VM (calculated) and C V (calculated) values and then tried to prove it from 9 data of Tertiary coals (p 167) At this stage he took recourse to CPT once again He could justify the limit for coals highly prone to spontaneous combustion in 5 out of 9 cases with success ratio of 0 55 Out of 4 failure cases in one case the C V (calculated) is more than 8000 cal/gm and in three cases the CPT is more than 140°C Nothing is said about moderately and least prone to spontaneous combustion coals A very sweeping inference has been resorted to Despite the above, the author claims that the model is applicable to all classes of Gondwana and Tertiary coals of India

10 At point four of the conclusion it is stated that VM (experimental) could form the basic data from which calculated values of VM and C V could be

obtained for classification of coal into one of the three categories of spontaneous combustion The proposed models are based on data given in Table 3 If data of Talchir coals are compared with those of Ib-valley and Raniganj, both experimental and computed values of VM in former case seem to be truncated The calculated values of VM obtained from Seyler's formula differ slightly from VM (calculated) shown in the table Further, in the first line of Table 3, dV for sample No L/5 should be 3 38 instead of 3 65 The final conclusions of the paper stand on these data So the conclusion might have been erroneous

11 There seems no justification for segregating the data of Tables 5 and 6 Some data of Table 5 (like moisture, ash, N, S, O values) are not relevant to the present study and there has been duplication of data of two columns (calculated values of C V and VM) in both the tables Data of both the tables could have been presented in one

12 The chi-square formula is not correctly represented It should have been $\chi^2 = (0 - E)^2/E$ Necessity of using chi-square test is not clear Neither the null nor the alternate hypotheses have been indicated Chi-square test is used for observed and expected data of similar type where $\Sigma O = \Sigma E$ However, the author has performed the test for quite different types of data like VM and C V as well as in both cases $\Sigma O=\Sigma E$ If at all the test is performed, in the first case (VM experimental and calculated) the computed value of chi-square should be 85 40392 instead of 109 326 and in the second case (VM and C V) the computed value should be 335130 5479 instead of 7005 92 as indicated When the number of data is 42 (Table 3) how the degrees of freedom could be 50?

13 The author has fitted straight lines to data sets VM *(experimental) vs* VM *(calculated) as well as* VM (experimental) *vs* C V (calculated) of Table 3 and confirms the existence of linear relationships Neither attempt has been made to fit higher order lines to the above mentioned data sets nor analyses of variance have been performed to test the significance of the fitted lines and unsuitability of other lines This is a serious lapse Unnecessary indication has been made about the constant term and regression coefficient values on which no comments have been given in the paper In the last sentence of p 167, reference has been made to Fig 11 It should have been Fig 10 instead

14 At the beginning part of p 169, the author has indicated X = VM (experimental) and Y = VM (calculated) i e VM (calculated) is to be computed from VM (experimental) However, in Fig 10, VM (calculated) is plotted along X-axis and VM (experimental) is plotted along Y -axis, which means VM (experimental) to be determined from VM (calculated) This is a very serious mistake because interchange of variables gives a totally different set of regression equations In fact, the author intends to calculate VM (calculated) from VM (experimental) i e in Fig 10 VM (experimental) should have been taken along X-axis and VM (calculated) should have been taken along Y-axis In this case the graph will be totally different from one shown in Fig 10 The corresponding 1st degree line is $Y = 14\ 798 + 0\ 5226X$ with $R^2 = 0\ 4663$, 2nd degree line is $Y = -27\ 957 + 2\ 4868X - O\ 0218X2$, with $R^2 = 0\ 6242$, 3rd degree line is $Y = -68\ 82 + 5\ 4186X - 0\ 0888X^2 + 0\ 0005X^3$, with $R^2 = 0\ 6332$ ANOVA suggests that 2nd degree line is better fitted than the 1st degree line In case of VM (experimental) *vs* C V (calculated) the 1st degree line is $Y = 9216\ 2 - 26\ 293X$ with $R^2 = 0\ 3999$, 2nd degree line is $Y = 11393 - 126\ 28X + 1\ 1107\ X^2$, with $R^2 = 0\ 5385$, 3rd degree line is $Y = 11177 - 110\ 85X + 0\ 758X^2 + O\ OO26X^3$, with $R^2 = 0\ 5386$ ANOVA suggests that 2nd degree line is better fitted than the 1st degree line in this case also Thus, the author has given wrong and misleading models/results No comment has also been made a bout the values of R^2

15 While testing the significance of correlation coefficients, the author has mentioned the degrees of freedom to be 50, which is not true when the number of data is 42 (Table 3) In p 169, while correlating the VM (experimental) with C V (calculated) the author wrongly states n (possibly number of data) = 51 Further mention has been made about the tabulated value of r (possibly for r-test), which is not relevant in the present case *At these stages also neither the null nor the* alternate hypotheses are mentioned It seems testing of the significance of correlation coefficient in case of bivariate data has not been properly attempted

16 In the latter part of the conclusion the author has indicated that VM (calculated) and C V (calculated) could be determined from VM (experimental) obtained from proximate analysis These are sufficient to predict the degree of spontaneous combustion in Indian coals This is, however, seen in 8 out of 9 cases of Tertiary coals only If the concept of CPT is introduced the overall success falls to 5 out of 9 cases (Table 6) No clear-cut relation is discernible in case of Gondwana coals of Ib-river, Talcher and Raniganj coals (Table 4) where data presentation is not clear

and classification is overlapping (e g moderately to highly prone) Further, wrong models have been given to calculate V M (calculated) and C V (calculated) from V M (experimental) values

17 From the above observations it can be safely inferred that the conclusions drawn from the study are based on insufficient data and incorrect statistical analyses As such the model proposed by the author cannot be universally applied for classification of Indian coals into different degrees of proneness to spontaneous combustion

P. Behera, P G Department of Geology, Utkal University, Vani Vihar, Bhubaneswar 751004, replies

I would like to thank Mr S C Nayak for taking so much of interest in my paper and reading it very critically The clarifications to his comments are as follows

1 References are given under the list of references

2 Table 1, this is after C S Raja Rao edited Bull of G S I ,No 45 The entire Table I has been taken from Raja Rao's G S I Bull No 45 v II, 1982

3 It may be taken as a case of organizational error

4 Page 160, right column Relation of stratigraphic sequence with CPT has been mentioned in the introduction chapter with references It is also written in the right column first sentence that there is a tendency of decrease of CPT from the older seam to the younger seam Hence, no further supporting figure was necessary

5 It is justified Please see Fig 2

6 The frame of Fig 2, reference has been given, Chandra and Prasad (1990), p 160, para 1, right column, ref Intl Jour Coal Geology, v 15, 1990 The dotted lines were used because of uncertainty

7 There are five seams of Rampur Seam i e , Rampur Sec 1 to 5 Average values have been taken for each section of the seam which are shown in Table 3 In the original work of the author (Ref given), 12 values are there In Fig 2 there is one plotting error for Talcher coals In Fig 9, the symbols in index have been interchanged between seam-1 and seam -2 However, all the figures are just to show the overall relation with CPT

8 The author points out compositional variation and its relation of vitrinite, exinite and inertinite etc with CPT but not with V M (Cal) or C V (Cal) The C V (Cal) values given in Table 4 is the average value for the corresponding seam

9 It may please be noted that it is not an arbitrary classification It is author's finding by careful study of the chemical analysis results of the Ib-valley coals, Talcher coals and Raniganj coals, all belong to Lower Gondwana coals This range has been tried on Tertiary coals which are all highly prone to spontaneous combustion All values are below 140°C CPT except two which are just 140±2°C

10 The dv for L/5 should be 3 38 instead of 3 65 It is a typographical error Both values indicate that coal is an abnormal one While calculating the value for V M (calculated), the author has omitted the decimal figures or rounded up the decimals to nearest whole numbers in certain cases This has been done just show the clarity in variation of the values in different seams

11 In Table 5,data on moisture, ash, S and 0 are given just to show how the Tertiary coals are high S coals and differ substantially from the Gondwana coals Table 6 shows the relation of V M (Cal) and C V (Cal) with CPT

12 The object is same i e same coal sample on which the two parameters are tested V M (experimental) has been taken as the observed value and V M (calculated) taken as expected value Number of samples is 51 and degrees of freedom is 50 In Table 3, the average values of some seams are shown For example RS5/M, RS4/M, RS3/M and one in Raniganj coals are there which had been taken into consideration but not shown in the table That is why values shown in the paper and your calculation differ V M (experimental) is taken as the independent variable and V M (cal) as well as C V (cal) as dependent variable

13 The author has worked on first order straight lines In future works higher order line fittings will be taken care of The author appreciates the valuable suggestion of Shri Nayak Currently the author is preparing another paper where higher order lines are being tested The last sentence of p 167, Fig 11 be read as Fig 10

14 In p 168, there is typographical mistake of V M (experimental) on Y-axis, it should be on X-axis in Fig 10

15 The Chi Square test has been performed by taking number of data 51 and d f as 50 where the Null Hypothesis and Alternate Hypothesis have been tested in relation of spontaneous combustion with stratigraphy Remarks are drawn accordingly Detailed explanation in point 12, but the regression analysis for the best fit line has been done by computer simulation The correlation coefficient r value obtained

from this data also amply supported the acceptance of Alternate hypothesis

16 In Table 4, the overall characterization of coals have been done on major coal seams of the Ib-valley, two major seams of Talcher belonging to two stratigraphic units and three units in Raniganj coalfield This vindicates the relation with stratigraphy of different seams Remarks are drawn accordingly

17 The model proposed is suitable to all varieties of coals of Indian origin The Chirimiri coals of Surguja district, M P has been tested as a case study and fits to this model (Ref Behera, P and Rout, A , 2004, Spontaneous combustion in coals—A case study, Vistas in Geological Research, v II, 2004), Utkal University, Bhubaneswar

(2)

S.K. Misra, Regional Research Laboratory, C S I R , Bhubaneswar - 751 013, comments

The paper by P Behera on the above theme is definitely a welcoming attempt However, a number of flaws and errors reduce the gravity of the topic and need to be clarified These are as follows

1 The present paper describes the systematics in the coals with a view to classify them on the degree of proneness to spontaneous combustion The dictionary meaning of panacea is "remedy for all ills/ difficulties - a universal remedy" Nowhere in the paper probable remedial measures to be undertaken to prevent spontaneous combustion in coals are mentioned Hence, the title of the paper is purely non-representative and misleading

2 It is well known that "the natural starting of a fire" in a coal seam is termed as spontaneous combustion which takes place due to oxidation of pyrite and resins in the coal Hence, any paper dealing with spontaneous combustion should refer to these two important components The abundance of resin/ resinite or pyrite (organic/inorganic) has neither been recorded by the author in the coal seams nor any reference on their quantification has been cited

3 The latest reference cited in the text is 1994 But relevant literature on this subject is available up to 2003 (see some of these references at the end) It needs to mention that a National Conference, (AusIMM, IEAUST, Brisbane) held in Australia (July 1997) had brought out many references suggesting different methods using calorimetry in some form to test the propensity of coals to spontaneous combustion There is no mention on the methodology/parameters for CPT used by the author in the paper The methodology and the condition of the experiment largely control the measurement of CPT value as has been shown by Chandra et al (1987)

4 There was no need to describe the stratigraphy of the coal seams in such type of paper If at all felt useful it is not understood why the stratigraphy of one field (Ib-valley) is mentioned with omission of other coal fields (Talcher, Raniganj and Upper Assam) Nowhere the information on sample location, stratigraphy etc of Arunachal Pradesh, Nagaland and Assam coals has been mentioned

5 Author has used the formula of Seyler (1938) in calculating volatile matter and calorific value This formula is pretty old Presently Indian Standard (IS 1350 Part 11-1970) and Mazumdar (1981) formula are widely used for Indian coals How has the author overlooked Mazumdar's formula, which brought revolutionary change in coal chemistry specifically with respect to Indian coals? If Mazumdar's formula is not suitable for such work, it should have been mentioned with justification References to Mazumdar's work (1981) cited at the end by the undersigned contains as many as 90 cross references

6 In the last paragraph under "STUDY AREAS, MATERIALS AND METHODS" the author has mentioned (p 160) that, "the chemical analysis data of C and H, volatile matter (experimental), volatile matter (calculated) and calorific value (experimental) of the Ib-valley coals have been shown in Table 3 " But surprisingly the calorific value of experimental data is missing from the said table and instead CV (calculated) is mentioned Moreover, the units of calorific value (Kcal/Kg or Cal/gm), H, C etc are omitted (Table 3)

7 The oxygen percentages of coal samples of Ib, Talcher and Raniganj have not been mentioned anywhere though the calorific value (calculated) has been mentioned in Table 3 If calorific value (calculated) mentioned in Table 3 is back calculated, following the formula mentioned by the author (calorific value = 388 1H+123 92C-4269+1/4O^2, the values of oxygen calculated by the undersigned come around 3-35% From available literature, the oxygen contents in such types of coal sample are within 13 18% (Mohanty, 2001) Such wide variation may be justified However around 50% calculated CV in Table 3 (last column) are wrong as per the formula cited by the author

Further, the literature indicates that the calorific value of coals from seam I & II of Talcher coalfield ranges from 3170 to 4900 KCal/Kg (Raja Rao, 1982) which is much lower than those indicated by author Presentation of proximate analysis on 60% RH and at 40°C basis and ultimate analysis result could have substantiated author's conclusion If author can provide the proximate and ultimate analysis of said samples it would be highly useful for the readers

8 The CPT *vs* maceral group plots (Figs 3-9) must be on the basis of various macerals contents present in different coals Author should provide the maceral distribution pattern in different coal types for the benefit of readers

9 In p 159, 3rd paragraph, 20th line, the author mentions "the exinite group includes a number of macerals such as sporinite, cutinite, alginite, resinite and vitrodetrinite" Inclusion of vitrodetrinite under exinite group is not as per ICCP system (1994) Hence, the author should provide the reference on inclusion of vitrodetrinite in exinite group maceral

10 It is not understood from the paper whether the maceral composition data used in various graphs are generated by the author or taken from other references In case the author used data from published references then these should be mentioned in list of references

11 Can any body draw conclusion that spontaneous combustion in coal is stratigraphically controlled by studying only 2 coal seams while 13 coal seams in Talcher Coalfield long been reported (Manjrekar et al 1998, Misra et al 2002)

12 In p 161, the author mentions "Moreover, anyone constituent like resinite may have a different chemical composition depending on the origin It may be noted that in Raniganj coals, appreciable amount of resinite has been found (Saxena et al 1990 referred to by the author) which must have been responsible for the increase in spontaneous combustibility of the Raniganj coals whereas micro constituents of exinite in the Ib-valley coals and Talcher coals oppose the spontaneous combustion" Both the statements are contradictory Resinite is one of the macerals under exinite (liptinite) group So when one maceral from a group supports combustion somewhere, how the same group will oppose it elsewhere?

13 In p 162, 2nd column, second paragraph, author states, "From the foregoing results, it was clear that spontaneous combustibility of coals was mainly guided by the rank of the coal but was modified by the maceral composition Vitrinite and semi-vitrinite showed positive response whereas resinite showed negative response Inertinite either remained inert or helped to enhance spontaneous combustion" In view of above statement, rank of different coal vs maceral distribution should have been given Further, author says inertinite remains inert and again inertinite helps to enhance spontaneous combustion? How such contradictory statements are justified?

14 In Table 3 (under the column sample no), 4 samples from seam II of Talcher coalfield are mentioned It is not understood as to how "J-Fire prone zone" and J-Bot Zone of seam II have separate entities How was it demarcated prior to the study

15 There is some confusion about the sample collected and locations shown in Fig 1 on p 161 Recent publication on this should have been referred (Acharyya, 2000) No description is available on Tertiary coals Indian standards for sample collection procedure or author's procedure, chemical analysis procedure etc should have been mentioned which would have strengthened the quality of the paper

P. Behera, P G Department of Geology, Utkal University, Vani Vihar, Bhubaneswar - 751004, replies

The author is thankful to Dr S K Mishra for going through the paper so thoroughly and giving his valuable comments My reply to his comments are as follows

1 As per Chambers dictionary the word Panacea means — *a universal medicine* In my paper the term has been used in a literary sense, the parameter proposed can universally be used for all varieties of coals to identify them for the degree of proneness to spontaneous combustion

2 The purpose of the paper was not to find out the causes of spontaneous combustion in different coalfields related to pyrite or resin/resinite Hence quantification bas not been done on that aspect

3 The methodology followed for CPT is there in author's previous work which is there in the reference list (Behera, P, 1991) This kind of paper doesn't need the description of methodology of CPT in detail The author has consulted relevant references mainly on spontaneous combustion of coal I think Dr Mishra must agree with me that the list of reference appended by him relates to other characteristics of coal

4 Since crossing point temperature (CPT) was guided

by stratigraphy or rank of coal, it was necessary to show the stratigraphy In case of Raniganj and Talcher coals it has also been proved that CPT is related to stratigraphy

5 The author's own Ph D work related to this paper was based on Seyler's formula Therefore, the author worked on the base formula of Seyler The formula may be old but it does not mean that it is not authentic Many authors are using that formula even today (D Chandra et al 2000)

6 Page 160, the calorific value (experimental) be read as calorific value (calculated) which has been shown in Table 3 The calorific value (experimental) does not show any specific relation with the degree of spontaneous combustion whereas the calorific value (calculated) shows The unit of calorific value be read as cal/gm

7 I agree that oxygen percentage should have been given in Table 3 Back calculation will not give correct result The oxygen percentage in Ib-coals varies from 7 26 to 15 30, in Raniganj it is 3 to 11 5 and for Talcher 8 3 to 12 7 In Raja Rao, 1982, the C V (exp) values vary from 3170 to 4900 Kcal/kg which will substantially differ from calorific value (calculated) While calculating the value for V M (calculated) the author has omitted the decimal figures or rounded up the decimals to nearest whole numbers in certain cases This has been done just show the clarity in variation of the values

8 The author's concern was to show the relation between CPT and different maceral groups, detailed maceral composition in tabular form would have enhanced the number of pages of the paper The presented figures are author's previous publications (Behera, 1991, Chandra et al 1993)

9 Page 159, 3rd paragraph, 20th line, the term vitrodetrinite be read as liptodetrinite

10 The maceral data used by the author is from author's published data (Behera, P, 1991, Chandra et al 1993)

11 There is no refutal that there are 13 coal seams explored in Talcher coalfield till today Seam-I belongs to the stratigraphic horizon of Karharbari Formation and Seam-II belongs to the stratigraphic horizon of Barakar Formation Since the CPT substantially varies, it is correlated that spontaneous combustion is stratigraphically controlled This has been taken from the published data (Niyogi, C , 1989) Niyogi has already shown that the CPT of Talcher coals are stratigraphically controlled

12 Page 161 The exinite group has different constituents, the properties of which differ Resinite helps in spontaneous combustion whereas others do not help in spontaneous combustion

13 The property of inertinite differs depending on the physical structure There are two types of inertinite - one compact and nonporous and the other one is porous (Mishra, B K and Bhagawan, D , 1994) Since the inertinite of Ib and Talcher coals was nonporous in nature, it did not help in spontaneous combustion

14 Niyogi (1989) had used this term as followed in mines locally

15 Details of sample collection and methodology followed has been given in author's Ph D thesis in detail which has been referred to in the paper

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GEOCHEMISTRY OF ULTRAMAFIC LENSES IN THE GRANITOIDS OF THE SOUTHEASTERN FLANKS OF SHIMOGA SUPRACRUSTAL BELT [KARNATAKA] WITH A NOTE ON THE DISTRIBUTION OF PLATINUM GROUP ELEMENTS AND MINERALS by T.C. Devaraju, T T Alapieti and R.J. Kaukonen. Jour. Geol. Soc. India, v 63, (4), 2004, pp.371.386

K.T. Vidyadharan, S. Paranthaman, Geological Survey of India, Bangalore and **K.N. Rao**, Geological Survey of India, Hyderabad comment

We compliment the authors for documenting the geochemistry of ultramafic lenses in the granitoids of the southeastern flanks of Shimoga supracrustal belt, Karnataka with a note on the distribution of platinum group elements and minerals The ultramafics are described as chromitites, dunites, peridotites, pyroxenite with original textures as well as mineralogy of rocks considerably modified by pervasive deuteric and low grade metamorphic alterations Chlorite and antigorite and Fe-Cr oxides are ubiquitous minerals Amphibole is abundant only in hornblendite Geochemically the ultramafics are described as of high Cr, high Mg, High Al and high Fe types with dominant high Cr and high Mg types and high Al and Fe types as local variants. The authors with the REE chemistry also describe the komatiitic bulk composition of parental magma as indicated by some high Cr and Mg ultramafites The chromite-dunite-peridotite-pyroxenite association strongly suggest that the ultramafic lenses of this area constitute parts of tectonically emplaced layered body The authors have reported PGE from the layered ultramafic body from east of Rangapura probably representing the early phases of deep-seated crystallization which entrapped as later crystallized chromite and silicates The ubiquitous hydrothermal alteration and low-grade metamorphism have not apparently caused significant migration of PGE

We have the following points to offer pertaining to this part of the supracrustal belt

1 Chromite bearing ultramafic lenses of this area were reported by earlier workers
2 Geological Survey India during the course of the programme on specialized thematic mapping in parts of toposheets 57C/1,2,6 & 7 falling in Chitradurga, Hassan and Chikmagalur districts, recently delineated a long linear belt called the "Antarghatta belt" (Paranthaman and Vidyadharan, 2004a,b) northwest of Arsikere-Banavara up to the southeastern part of the Shimoga Schist belt extending for more than 50 km in strike and 500 m average width with intrusive and extrusive ultramafic bodies within the Peninsular Gneissic Complex
3 While the intrusive ultramafics show chromite layering and tholeiitic nature, the extrusive variants exhibit excellent pillow, nodular, ocellar structures (rare spinifex texture also) indicating undoubted komattiite affinity Associated with these mafic-ultramafic variants of the two suites meta- pelites like fuchsite-magnetite quartzites are also recorded from this area Pre-tectonic gabbro and post-tectonic dolerite dykes traverse the ultramafic belt
4 EPMA mineralogy of samples from this layered body indicated ferro aluminous, magnesio ferriferous and magnesio chromites, chrome magnetite, magnetite and magnesio manganese ilmenite Tremolite, serpentine,