The authors have performed an extensive review of literature data on sedimentary "red beds" in order to highlight their mineralogical and chemical signature, with respect to global databases on igneous, metamorphic and sedimentary rocks. The review shows that the "red beds" span a huge range in mineralogical and chemical composition. In terms of major elements, the most distinctive feature is the high Fe2O3/FeO ratio and the low Na2O/K2O ratio; However, as correctly acknowledged by the authors, XRF (hand held or lab) does not permit to quantify the iron oxidation state and this technique has very poor precision on light elements like Na2O. This make the application of the in situ analysis very tricky/impossible, as the main discriminant factors cannot be quantified by XRF; The analysis is very preliminary and based on basic statistics of rock composition in terms of major elements. More complete statistical analysis (for instance, PCA) could permit better to quantify the combination of major elements potentially specific of these rocks, in spite of their highly variable signature. Moreover, trace elements or other chemical signatures (stable isotopes) might result to be more reliable to identify red beds, for instance; In spite of the above-mentioned critical limitations of the current study, the two reviews have resulted in surprisingly minor modifications of the initial submission and cannot be considered as conclusive. I suggest paper re-submission after substantial modification (statistical data treatment; discussion on the in situ measurement of Fe2O3 and Na2O) of the current version of the paper.

Response: Thank you very much for your suggestions on this manuscript. We will answer the questions raised by the editor in the following three points:

(1) This manuscript adopts a novel YL-P-3LRX Handheld Laser Induced Breakdown Spectroscopy, which can quickly detect Na elements and achieve high-precision detection of Na_2O/K_2O ratio. Additionally, the rapid detection of Fe^{2+} and Fe^{3+} is indeed very difficult (Chen et al., 2019), which exceeds the detection range of handheld laser-induced breakdown spectroscopy in this manuscript and similar devices. But this factor does not affect the reliability of the quantification criterion for red beds recognition. Ignoring Fe_2O_3/FeO in Equations 1~6, the reliability of the red beds recognition quantification criterion can still reach 95.8% when detecting red beds. In the future, if there are new devices that can quickly detect Fe^{2+} and Fe^{3+}, the recognition efficiency of the red beds recognition quantification criterion in this study will be higher.

2.2 Criterion verification Lines 181-185

"After on-site sampling, use a hammer to smash the rock block out of the fresh surface. Then, the fresh surface was analyzed using the YL-P-3LRX Handheld Laser Induced Breakdown Spectroscopy (LIBS, Figure 3) to check whether these elements conform to the basic chemical compositions combination rules of red beds proposed by this study. This device can detect elements such as K, Na, Si, Al, Ca, Mg, Fe, and oxides."

3.5 Red beds identification quantization criterion verification Lines 372-386

"The chemical composition combinations of the 15 selected rocks in this study are shown in Table 5. Study has found that, The rapid detection of Fe^{2+} and Fe^{3+} is very difficult (Chen et al., 2019) and exceeds the detection range of handheld laser-induced breakdown spectroscopy in this manuscript and similar devices. But this factor does not affect the reliability of the quantification criterion for red beds recognition. F1~F5 and F are considered as 6 evaluation indicators, and there are a total of 72 (6 × 12) evaluation indicators for the 12 types of red beds. Among them, 3 evaluation indicators exceed the scope of the quantification criterion for red beds identification (F4 of numbered 7, 9, and 11 red beds with green background in Table 5 is less than the quantification criterion), indicating that the reliability of detecting these 12 types of rocks belonging to the red beds is as high as 95.8%. And for 3 non red beds rocks (limestone, arkose, and mudstone), there are a total of 18 evaluation indicators, of which 13 exceed the scope of the quantification criterion for red beds identification (indicated by blue background), indicating a high reliability of 72.2% in detecting these three types of rocks that do not belong to the red beds. Therefore, this study proposes a quantitative criterion for red beds recognition with high reliability. In the future, if there are new devices that can quickly detect Fe^{2+} and Fe^{3+}, the recognition efficiency of the red beds recognition quantification criterion in this study will be higher."

(2) Based on the basic statistics of the major element composition of rocks, this study can serve as a preliminary standard for identifying red beds. Through PCA analysis, the principal components of the major element composition of rocks were obtained, which can better quantify the combination of these major elements in rocks and obtain more accurate quantitative criterion for identifying red beds.

3.4 Principal component analysis and quantitative criterion for red beds identification Lines 340-369

"Based on the preliminary quantitative criterion for identifying the red beds mentioned above, this section presents PCA statistical analysis (dimensionality reduction) of the $SiO_2+Al_2O_3$, Al_2O_3/SiO_2, $FeO+Fe_2O_3$, Fe_2O_3/FeO, K_2O+Na_2O, Na_2O/K_2O, $CaO+MgO$, and MgO/CaO of red beds in Figures 7 and 8. The result is significant with $P<0.05$ (Table 3), rejecting the null hypothesis. There is correlation between the variables, and principal component analysis is effective. It can be seen that the cumulative variance interpretation rate of the first five principal components reaches 94.788% (generally greater than 90% is sufficient), indicating that using the first five principal components can be well used for red beds recognition.

Table 3. Variance explanation

Components	*Characteristic roots*	*Variance interpretation rate (%)*	*Cumulative variance interpretation rate (%)*

1	2.700	33.754	33.754
2	2.249	28.112	61.866
3	1.169	14.613	76.479
4	0.882	11.023	87.503
5	0.583	7.285	94.788
6	0.263	3.293	98.081
7	0.131	1.638	99.72
8	0.022	0.280	100.00

According to the component matrix (Table 4) obtained during the PCA analysis process, the calculation equations for 5 principal components F1~F5 (Equations 1-5) and the calculation formula for the overall principal components F (Equation 6) can be obtained.

Table 4. Principal component matrix

Chemical composition combinations	Principal component 1	Principal component 2	Principal component 3	Principal component 4	Principal component 5
$SiO_2+Al_2O_3$	0.274	-0.281	-0.115	-0.014	-0.009
Al_2O_3/SiO_2	0.085	0.356	0.283	-0.199	-0.352
$FeO+Fe_2O_3$	-0.103	0.334	-0.071	0.449	0.702
Fe_2O_3/FeO	0.194	0.038	0.268	0.827	-0.449
K_2O+Na_2O	0.213	0.046	0.609	-0.336	0.16
Na_2O/K_2O	-0.092	-0.288	0.452	0.179	0.71
$CaO+MgO$	-0.331	0.05	0.289	-0.153	-0.195
MgO/CaO	0.276	0.196	-0.162	-0.203	0.575

$$F1 = 0.274 \times (SiO_2 + Al_2O_3) + 0.085 \times \left(\frac{Al_2O_3}{SiO_2}\right) - 0.103 \times (FeO + Fe_2O_3) + 0.194 \times \left(\frac{Fe_2O_3}{FeO}\right) + 0.213 \times (K_2O + Na_2O) - 0.092 \times \left(\frac{Na_2O}{K_2O}\right) - 0.331 \times (CaO + MgO) + 0.276 \times \left(\frac{MgO}{CaO}\right) \quad (1)$$

$$F2 = -0.281 \times (SiO_2 + Al_2O_3) + 0.356 \times \left(\frac{Al_2O_3}{SiO_2}\right) + 0.334 \times (FeO + Fe_2O_3) + 0.038 \times \left(\frac{Fe_2O_3}{FeO}\right) + 0.046 \times (K_2O + Na_2O) - 0.288 \times \left(\frac{Na_2O}{K_2O}\right) + 0.05 \times (CaO + MgO) + 0.196 \times \left(\frac{MgO}{CaO}\right) \quad (2)$$

$$F3 = -0.115 \times (SiO_2 + Al_2O_3) + 0.283 \times \left(\frac{Al_2O_3}{SiO_2}\right) - 0.071 \times (FeO + Fe_2O_3) + 0.268 \times \left(\frac{Fe_2O_3}{FeO}\right) + 0.609 \times (K_2O + Na_2O) + 0.452 \times \left(\frac{Na_2O}{K_2O}\right) + 0.289 \times (CaO + MgO) - 0.162 \times \left(\frac{MgO}{CaO}\right) \quad (3)$$

$$F4 = -0.014 \times (SiO_2 + Al_2O_3) - 0.199 \times \left(\frac{Al_2O_3}{SiO_2}\right) + 0.449 \times (FeO + Fe_2O_3) + 0.827 \times \left(\frac{Fe_2O_3}{FeO}\right) - 0.336 \times (K_2O + Na_2O) + 0.179 \times \left(\frac{Na_2O}{K_2O}\right) - 0.153 \times (CaO + MgO) - 0.203 \times \left(\frac{MgO}{CaO}\right) \quad (4)$$

$$F5 = -0.009 \times (SiO_2 + Al_2O_3) - 0.352 \times \left(\frac{Al_2O_3}{SiO_2}\right) + 0.702 \times (FeO + Fe_2O_3) - 0.449 \times \left(\frac{Fe_2O_3}{FeO}\right) +$$

$$0.16 \times (K_2O + Na_2O) + 0.71 \times \left(\frac{Na_2O}{K_2O}\right) - 0.195 \times (CaO + MgO) + 0.575 \times \left(\frac{MgO}{CaO}\right) \quad (5)$$

$$F = (0.338/0.948) \times F1 + (0.281/0.948) \times F2 + (0.146/0.948) \times F3 + (0.11/0.948) \times F4 + (0.073/0.948) \times F5 \quad (6)$$

Substituting the relevant data of the red beds in Figures 7 and 8 into Equations 1~6 can calculate the quantitative criterion for the red beds: F1=-3.36~23.55, F2=-23.00~3.11, F3=-10.12~4.88, F4=-2.21~4.52, F5=-0.97~7.30, and F =-0.67~1.89."

(3) This manuscript focuses on the study of the basic chemical composition combinations and quantitative criterion of red beds in the field of geological hazards. According to previous research, geological hazards are to some extent related to the mineral content of red beds, and the main components of these minerals are major elements such as Si, Al, Na, K, Fe, Ca, and Mg. Therefore, this manuscript conducts research on these major elements. Trace elements or stable isotopes can also reliably identify red layers, but they are not the main focus of this manuscript and will be studied separately as our research direction in the future.

2.1 Data collection Lines 159-167

"Studies have found that rock disasters are related to the content of minerals such as quartz, clay minerals, hematite, calcite, dolomite, feldspar, etc., and these mineral contents are also closely related to the combination of major elements or oxides (Table 1), for example, SiO_2 and Al_2O_3 (used to study the relative content relationship between quartz and clay minerals) (Hong et al., 2009), Fe_2O_3 and FeO (used to study the high content characteristics of hematite) (Hu et al., 2006), CaO and MgO (used to study the content relationship of potassium feldspar, calcite, and dolomite) (Han et al., 2023), Na_2O and K_2O (Qiao et al., 2017). Therefore, this study on the basic chemical composition combination rules and quantitative criterion of the red beds only involves the major elements mentioned above, and does not involve the analysis of trace elements or other stable isotopes."

Minor remarks

Linz 143 and Figure 2 « Mudstone » instead of « Mudtone »

Response: Modified "Mudtone" to "Mudstone" in manuscript

Table 1 and Table 2 : add to the caption "from literature data"

Response: Added "from literature data" to the caption of Tables 1 and 2

Table 3 : red beds need to be identified in the caption or in the table and discriminated with respect to the other rocks.

Response: The red beds has been distinguished from other types of rocks in Table 5

(formerly Table 3)