

Introduction

Study of elemental depletion is one way to understand the chemical composition of the ISM. The elemental depletion study is an indirect but powerful way to study interstellar grain composition. The depletion of the various condensable elements yields qualitative evidence for their inclusion in dust, and they also have potential to yield important quantitative information on the probable distribution of those elements in the solid material. The approach of the present study is to concentrate on how the depletion of different elements are found to correlate with each other, irrespective of any external factors, but with the recognition that the severity of the depletions generally differ in a systematic way from one location to another and from one element to the next. In the present study, we have examined the depletion of some important elements (considering their dominant ionization states) towards a large number of targets (290 sight lines) in order to search for new systematic effects in the behavior of depletion using the data from the recent compilation of column densities (Gudennavar et al. 2011). The calculated depletion of elements is compared with each other and also with different line of sight parameters. This study throws a light on the possible formation and processing of interstellar dust grains and related matters of the ISM.

The approach of the present study is to concentrate on how the depletions of different elements are found to relate to each other, irrespective of any external factors, but with the recognition that the severity of the depletions generally differ in a systematic way from one location to another and from one element to the next. In order to understand, how the depletion behaves under different conditions, it is necessary to compare the depletion trends for pairs of elements over different lines of sight. This comparison of elemental depletions will be the basis for the present study.

The depletion of an element X is calculated using the equation,

$$\delta(X) = \left[\frac{X}{H} \right]_g / \left[\frac{X}{H} \right]_{Standard}$$

In the logarithmic form,

$$D(X) = \log \delta(X) = \log \left(\frac{X}{H} \right)_g - \log \left(\frac{X}{H} \right)_{Standard}$$

Where X (or N(X)) and H (or N(H) = N(H I) + 2N(H₂)) are the column densities of an element X and total hydrogen in a given line of sight.

Data and Analysis

Recently Gudennavar et al. (2011) have compiled a large sample of interstellar column densities into a single database, which comes from space-based (e.g. Savage & Lehnner, 2006) and ground-based observations (e.g. Welty & Crowther, 2010). The primary goal in this was to make these data accessible to a large community as a tool for estimating the distribution of gas and dust in our Galaxy. The present study on Interstellar elemental depletion makes use of the data on column densities of various elements in different sight-lines. Elements covered in the present study include iron, magnesium, silicon, oxygen, phosphorus, sulfur, titanium, calcium, manganese, zinc, and sodium. We have also investigated the dependence of parameters like mean hydrogen volume density n(H), f(H₂) and E(B-V)/d (cloud and dust parameters) on interstellar elemental depletion. A sample table of calculated parameters is given below.

Star Name	n(H)	f(H ₂)	E(B-V)/d	D(Fe II)	D(Si II)	D(Ti II)	D(P II)
HD 120315	1.0081E-02	5.143E-05	2.667	-1.07	-0.40		
HD 116658	4.0510E-02	1.778E-06	0.375	-1.31	-1.30	-1.57	0.83
HD 147933	1.2454E+01	3.541E-01	4.324	-2.24	-1.62	-2.95	-1.70
HD 143275	3.8971E+00	3.541E-02	0.000	-1.84	-1.11		-0.64
HD 147888	1.4919E+01	2.579E-01	3.760	-2.38	-1.19	-3.08	
HD 141637	3.4113E+00	9.499E-02	0.987	-1.91	-1.25	-2.41	-0.67
HD 44743	4.2263E-03		0.000	-0.47	0.53	-0.71	
HD 144217	2.7445E+00	1.121E-01	1.288	-1.85	-1.07	-2.76	-0.61

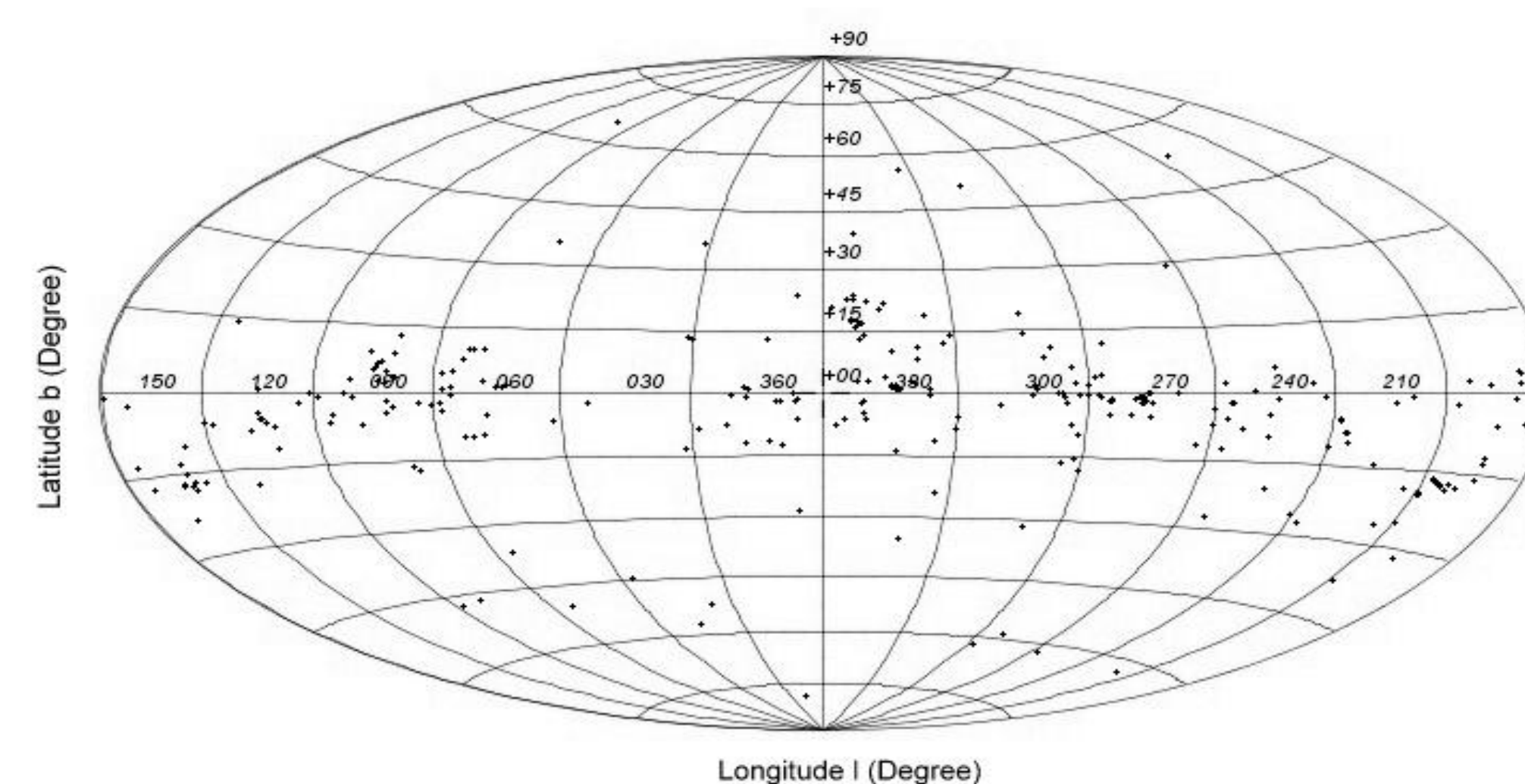


Fig. 1. Distribution of stars included in our data set, in the Galaxy with centre at galactic latitude, b = 0.

Sample plots

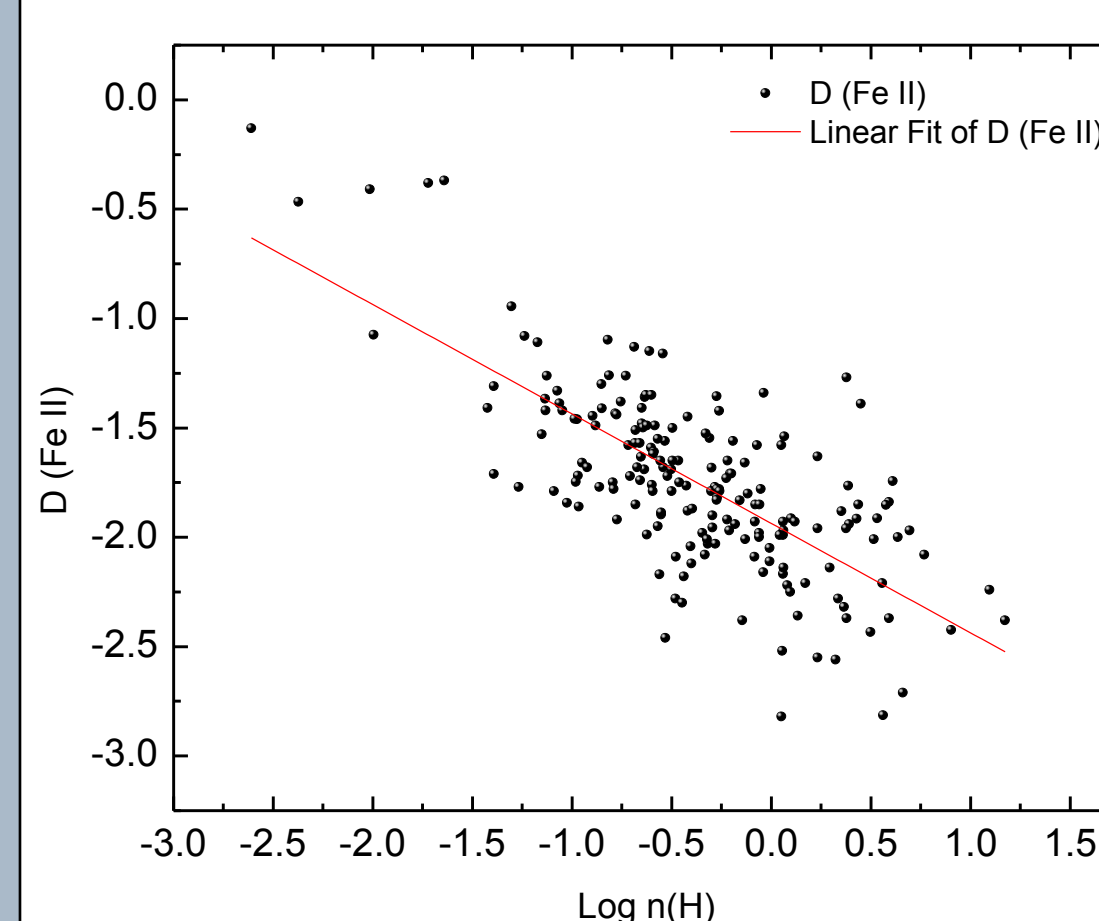


Fig. 2. Iron depletion against mean hydrogen density.

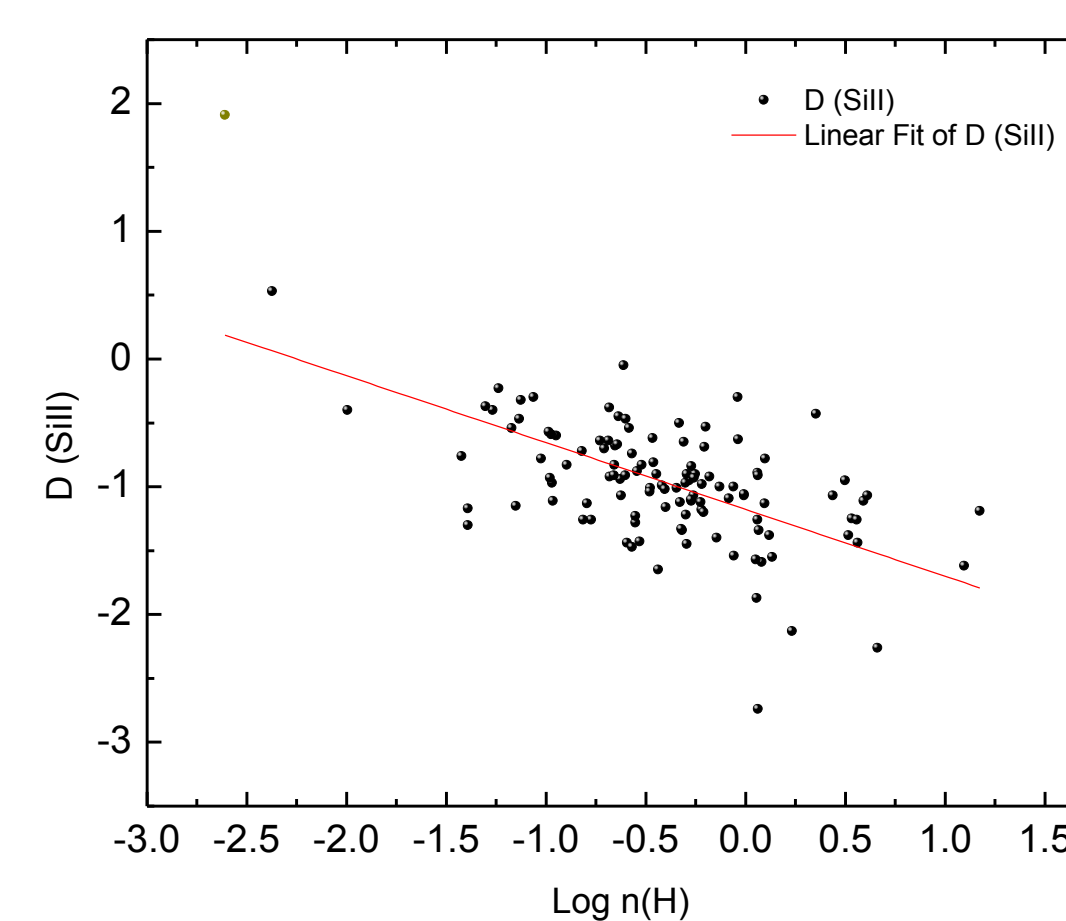


Fig. 3. Silicon depletion against mean hydrogen density.

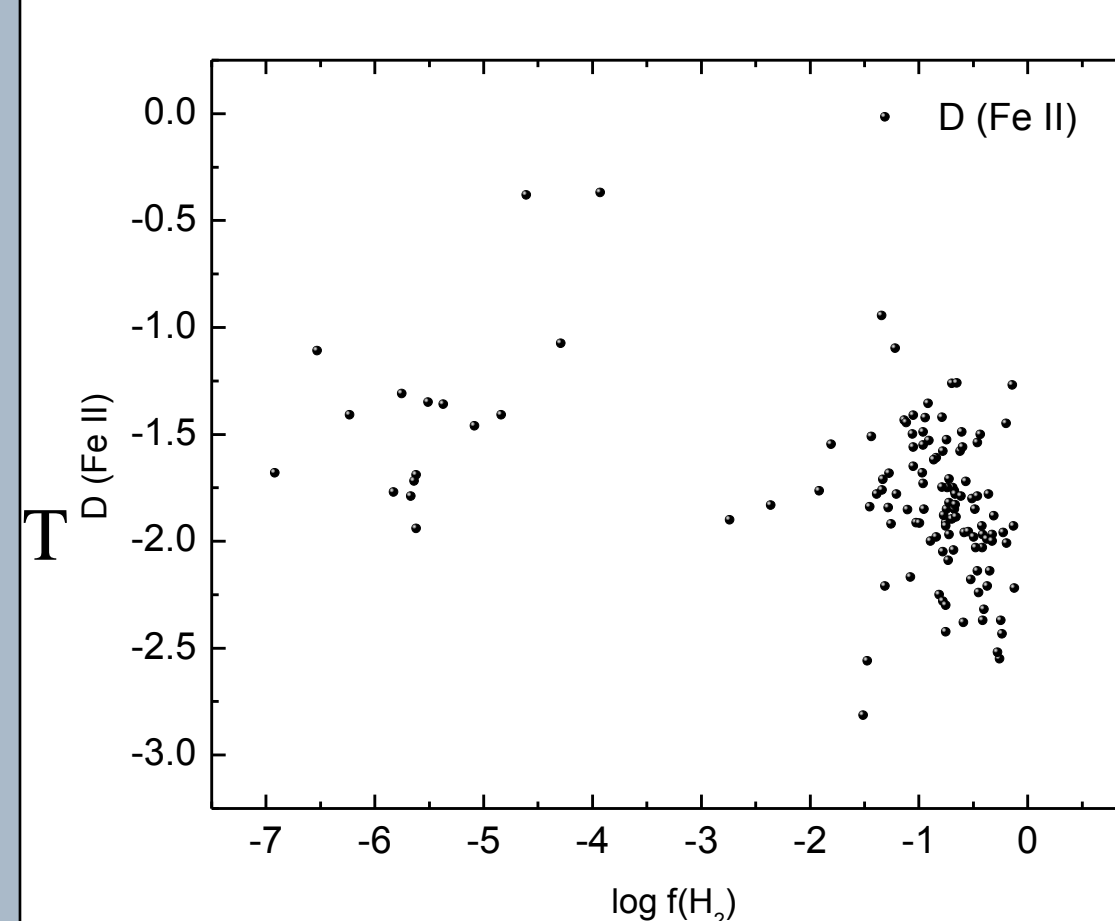


Fig. 4. Iron depletion against fraction of hydrogen in molecular form.

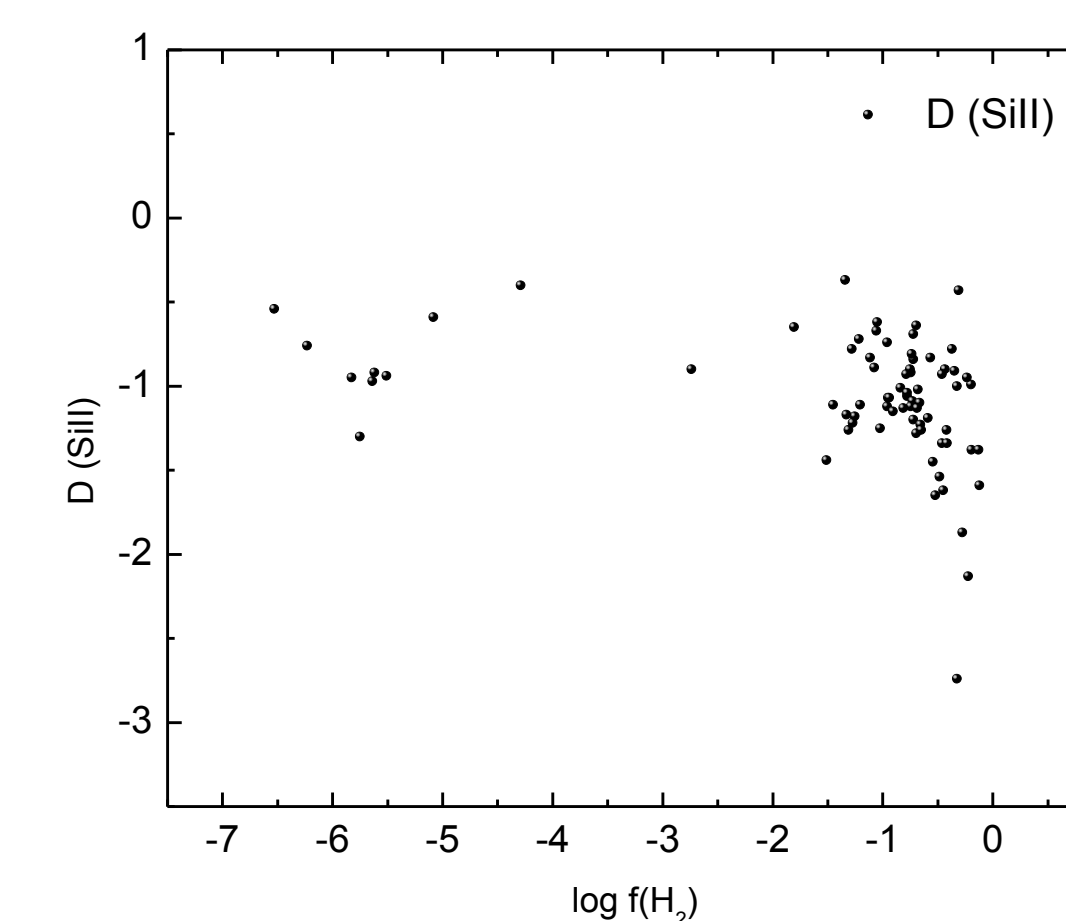


Fig. 5. Silicon depletion against fraction of molecular hydrogen.

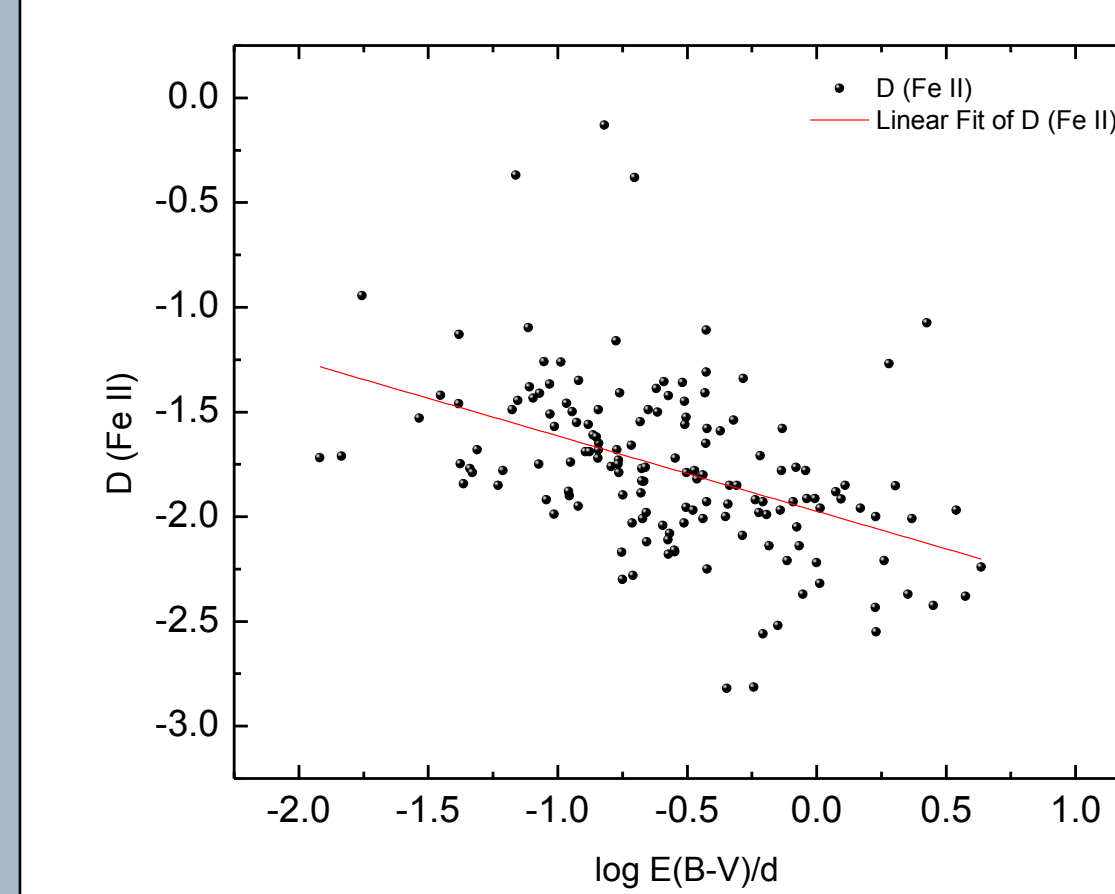


Fig. 6. Iron depletion against the reddening per unit distance.

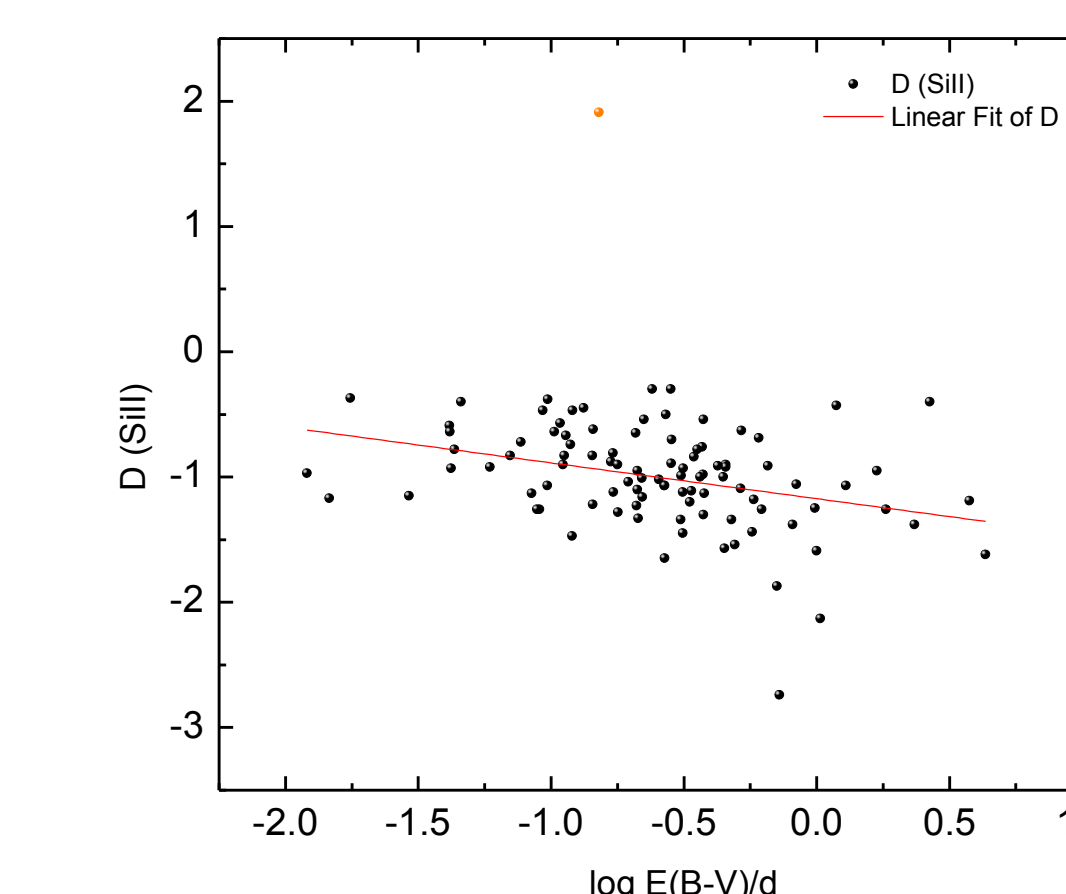


Fig. 7. Silicon depletion against reddening per unit.

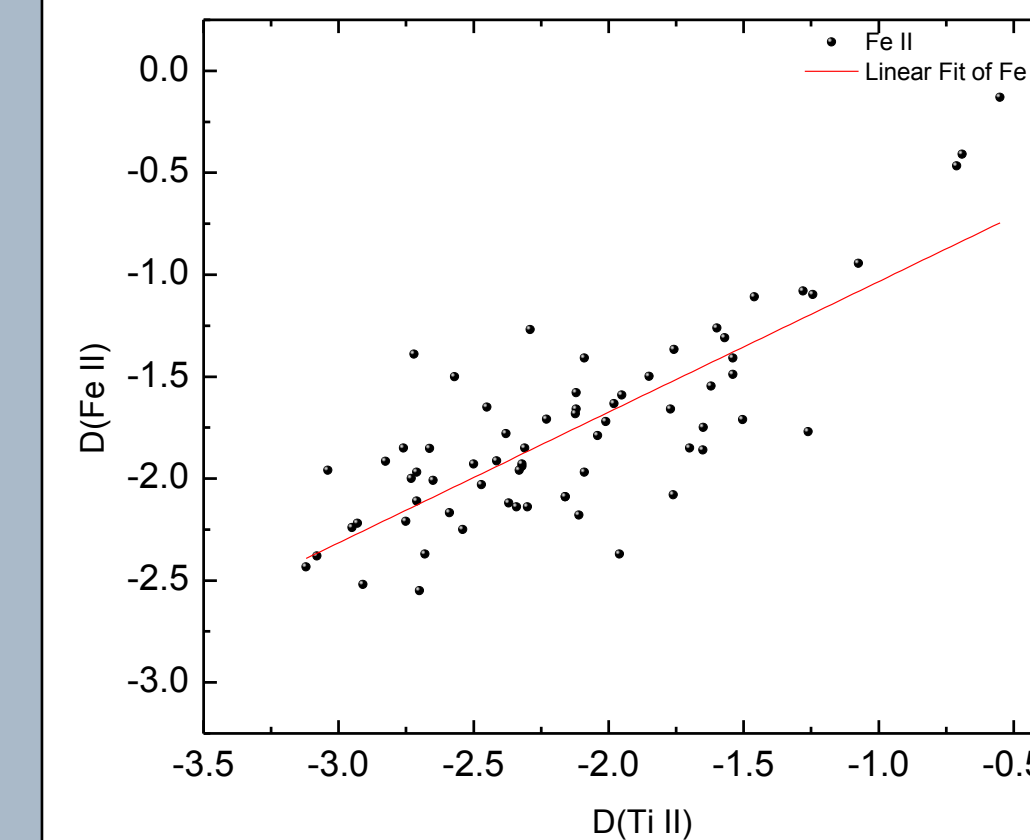


Fig. 8. Depletion of Iron versus titanium

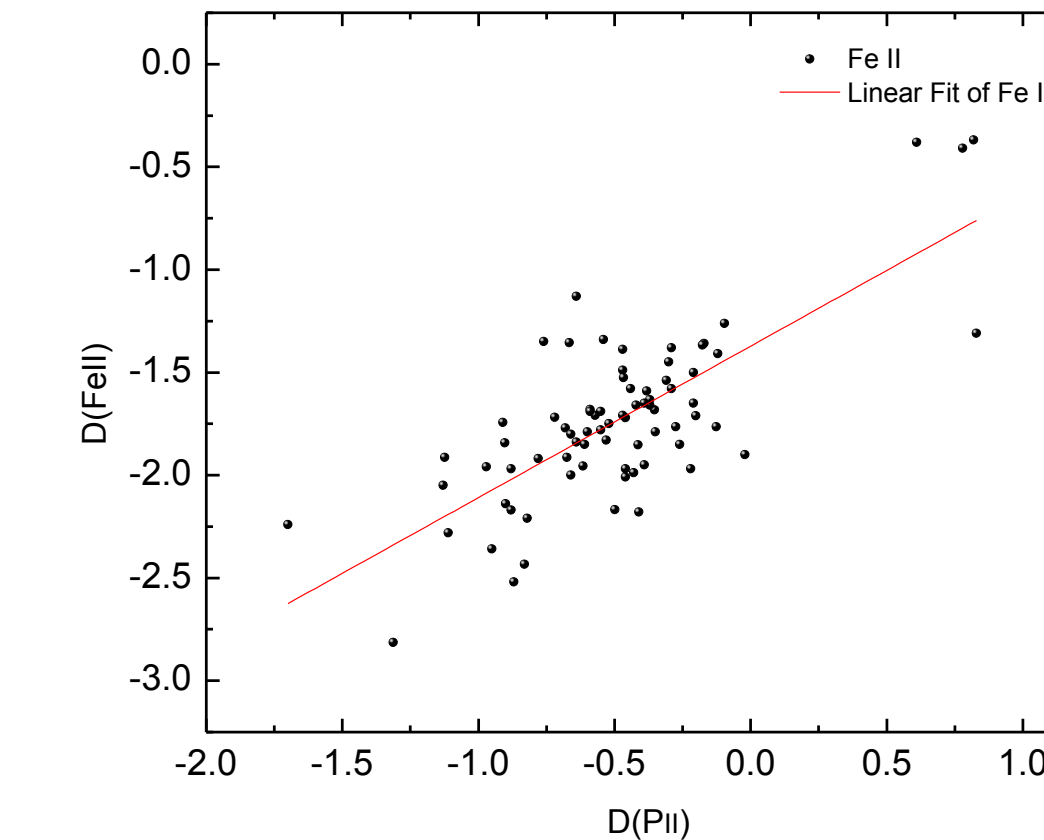


Fig. 9. Depletion of Iron versus Phosphorus.

Results and Conclusions

- The interstellar elemental depletion varies with line of sight conditions.

- For most of the elements the plot between depletion and n(H) or E(B-V)/d shows a dependence, which means depletion is greater in the denser regions.

- Depletion of Ti, Fe, Ca, P and Si shows a reasonably good dependence with mean line of sight space density n(H). Elements such as Mg, Mn, and S have lesser dependence and, Na, O, Zn show no dependence with n(H).

- The depletion of elements like Fe, Mg, Si, Ti, Mn, S, and P shows a dependence with fractional abundance of hydrogen in the molecular form f(H₂). Some depletion pattern seen with fraction of hydrogen in molecular form may be due the interdependency of f(H₂) and n(H). From the plots, we can see that depletion is definitely greater in those regions with f(H₂) ≥ 0.1.

- The depletion of elements like Ca and Ti shows fairly tight correlation with average reddening. Fe, Mg, Mn, Si and P show less but dependence with fractional abundance of hydrogen in the molecular form f(H₂). But Na, O, S, and Zn show no dependence with E(B-V)/d.

- Iron depletion is linearly correlated with depletion of silicon, titanium.

- We also obtained the first evidence for a correlation between iron depletion and phosphorus depletion.

- Magnesium also shows a linear correlation with depletion of titanium, sulphur and phosphorus.

- Silicon depletion is correlated with titanium, sulphur and iron,

Future plans

As the previous studies give no clear understanding of the elemental depletion correlations among various elements as well as the dust & cloud parameters, in the present study, we have made an attempt to get some insights about the interstellar dust processing and evolution through depletion studies. This is an impetus for further study on the dust composition and processes in the interstellar medium. The work will be continued to understand the various aspects of interstellar medium.

References

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