Open Journal of Geology, 2015, 5, 106-114
Published Online March 2015 in SciRes. http://www.scirp.org/journal/ojg
http://dx.doi.org/10.4236/ojg.2015.53010

Tectonic Geomorphology of Atrak River, NE Iran

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Received 9 February 2015; accepted 7 March 2015; published 12 March 2015

Abstract

Atrak River region, northeast Iran is a quaternary tectonically active region. There are many geologic structures that they are formed by the collision of the Arabian and Eurasian plates. This area has extended from north east Iran to the of kope dagh zone. The study area is Atrak river basin and it has been divided to 56 Sub-basin for calculation of 6 geomorphic indices. Finally, this region was classified in 4 relative tectonic activity classes.

Keywords

Atrak, Kope Dagh, Geomorphology, River, Basin, Iran

1. Introduction

Neotectonics is a major factor controlling landform development in quaternary tectonically active regions. The effect factors in morphology region are tectonics, lithology, climate and human. If tectonic has been most effective factor in region, it's related to tectonic geomorphology. The study area (**Figure 1**) of Atrak River basin is at north east of Iran [1] [2]. The river is located in the Kope dagh and Atrak basin is divided to 56 sub-basins (**Figure 2**).

This area belongs to Kope dagh province [3]. Dominant structural trend in Kope dagh province (**Figure 3**) is NW-SE. From tectonics view, it contains the Kope dagh hinterland or Kope dagh fold and thrust belt that formed in passive margin of Eurasian plate until late Triassic and then marine sedimentation on Kope Dagh proforeland basin has continued to Eocene. Kope dagh hinterland has uplifted related to Karakorum foreland basin in northeast along Eshghabad fault.

The western part of studied area has located in South Caspian foreland basin. Dominant structural trend in

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How to cite this paper: Mosavi, E.J. and Arian, M. (2015) Tectonic Geomorphology of Atrak River, NE Iran. *Open Journal of Geology*, **5**, 106-114. http://dx.doi.org/10.4236/ojg.2015.53010

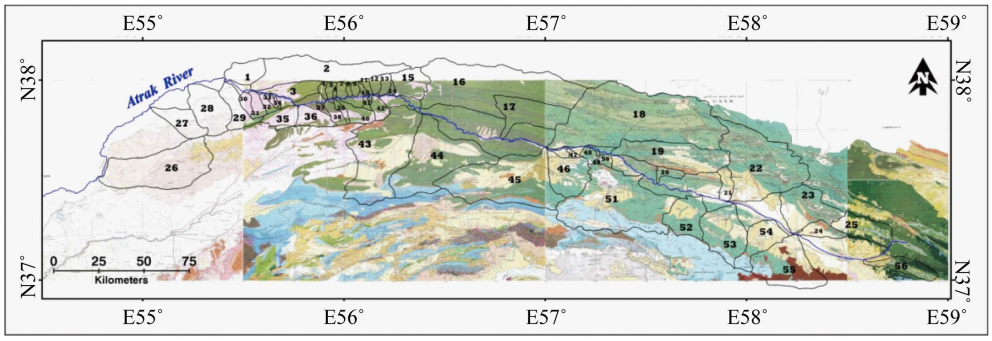


Figure 1. Location of the study area.

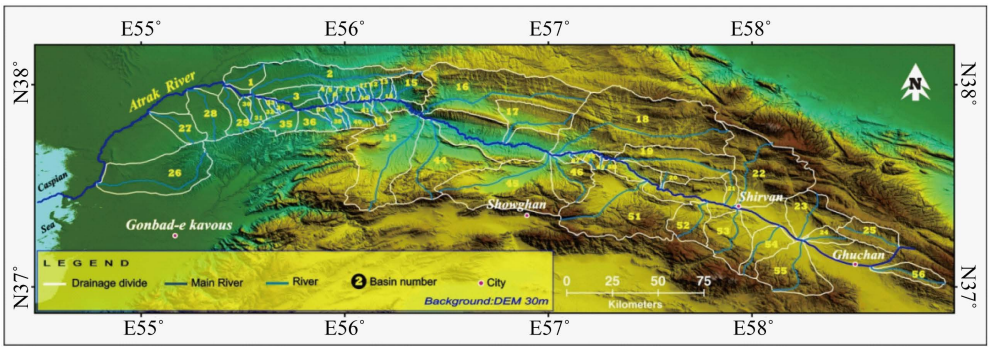


Figure 2. Fifty six sub-basins of the Atrak River basin.

South Caspian foreland basin province (**Figure 3**) is NW-SE. From tectonics view, it contains the northern foreland basin of West-Central Alborz and lesser Caucasus hinterland in the south margin of Eurasian plate since late Eocene. Although median part of South Caspian and Black sea basin has uplifted by collision between Eurasian and Cimmerian plates [3].

This area has semi active tectonics regim in compared to Alborz [4]-[11], Central Iran [12]-[18] and Zagros in the southern Iran [19]-[22].

2. Materials and Methods

This article applies a quantitative geomorphologic method to an area in the Zagros to evaluate rates of active tectonics. Considering the diversity of the morphotectonic features [23] [24]. Spatial tools including geographic information systems (GIS) and morphometric analyses may provide useful information on this subject, we have analyzed below geomorphic indices by [25] method (**Table 1**). Also, results were shown in **Figure 4**.

To study the indices, there is a formula which we turn to describe each one of indices; It is necessary to have some primary maps to calculate the indices, and the most important of which are: Digital Elevation Model (DEM), the drainage network and the sub-basins map of the Atrak basin that have been extracted from DEM. DEM (SRTM) extracted from a digitized topographic map (1:30,000).

1—the stream-gradient index (SL): $SL = (\Delta H/\Delta L)\, L$;

2—drainage basin asymmetry (Af): $Af = (Ar/At)\, 100$;

3—hypsometric integral (Hi): $Hi = (\text{average elevation} - \text{min. elev.})/(\text{max. elev.} - \text{min. elev.})$;

4—valley floor width-valley height ratio (Vf): $Vf = 2Vfw/(Ald + Ard - 2Asc)$;

5—drainage basin shape (Bs): $Bs = Bl/Bw$;

6—mountain-front sinuosity index (Smf): $J = Lj/Ls$.

3. Results and Discussion

We computed a single index (Iat) from the six indices to characterize relative active tectonics. Previous studies in Iran [26]-[42] tend to focus on a particular mountain front or area to discuss relative tectonic activity and

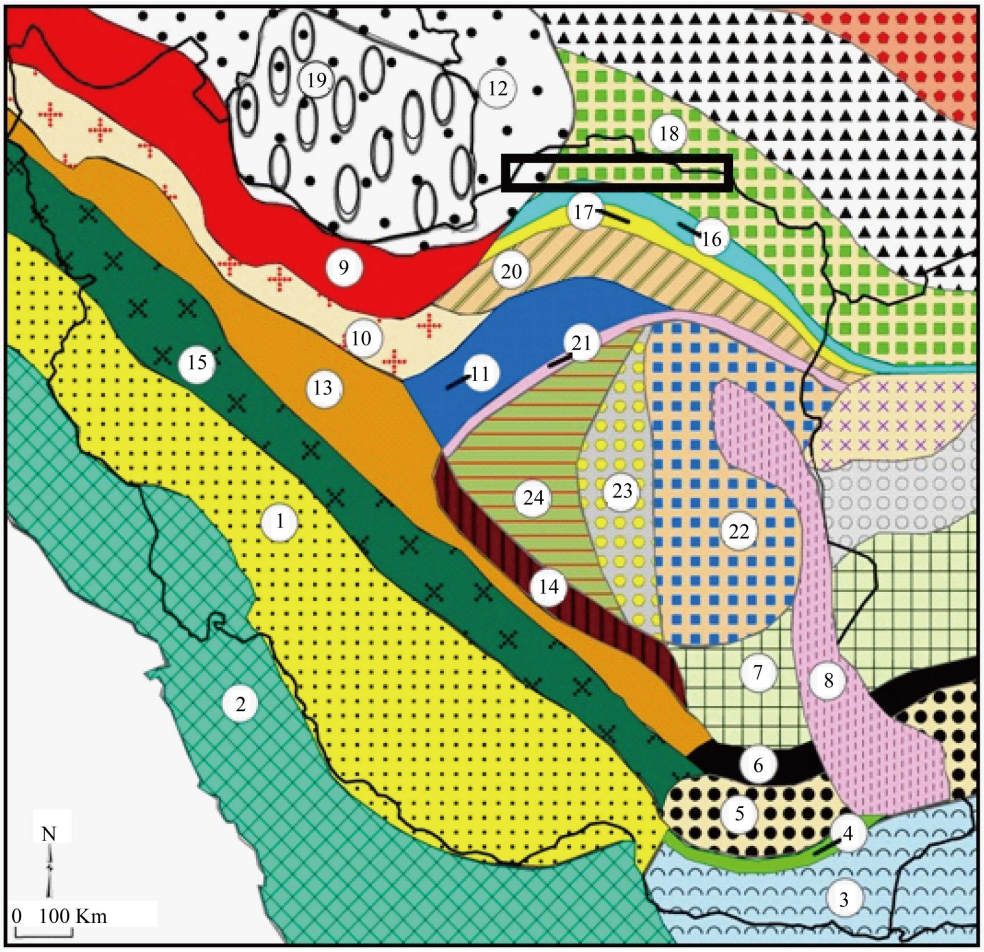
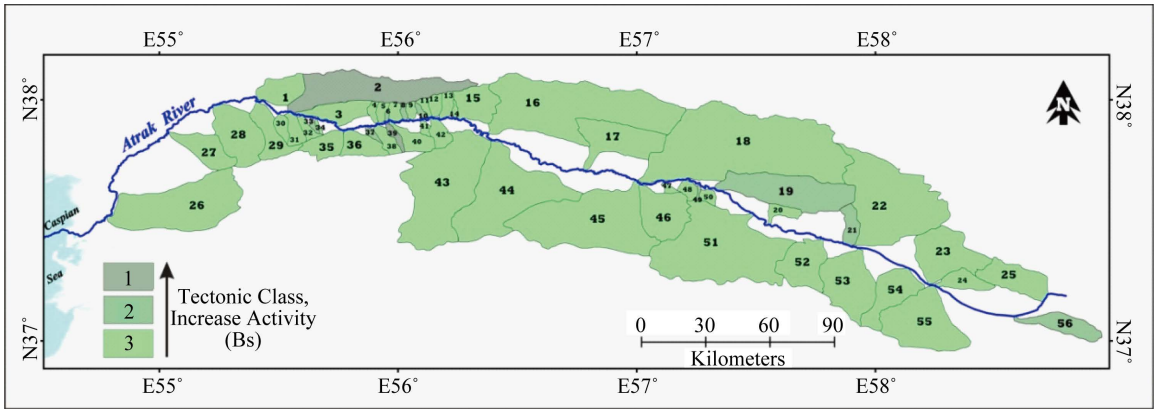
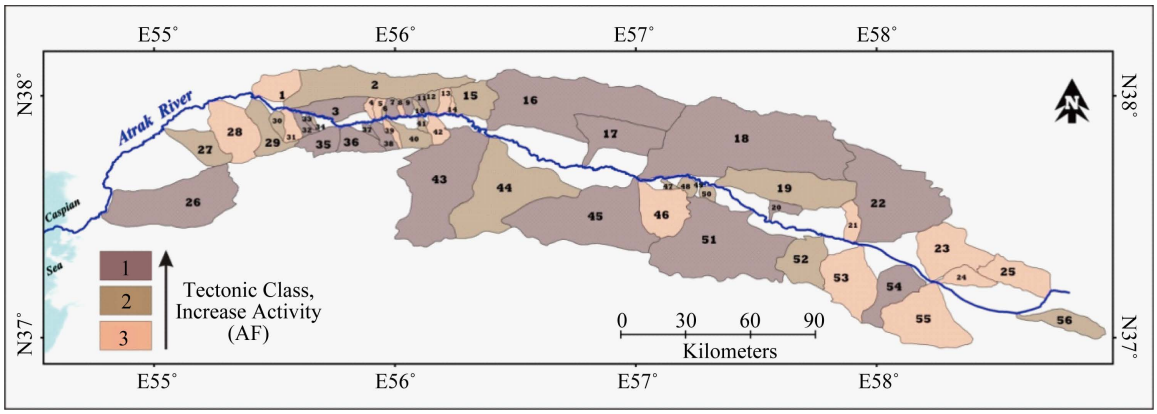


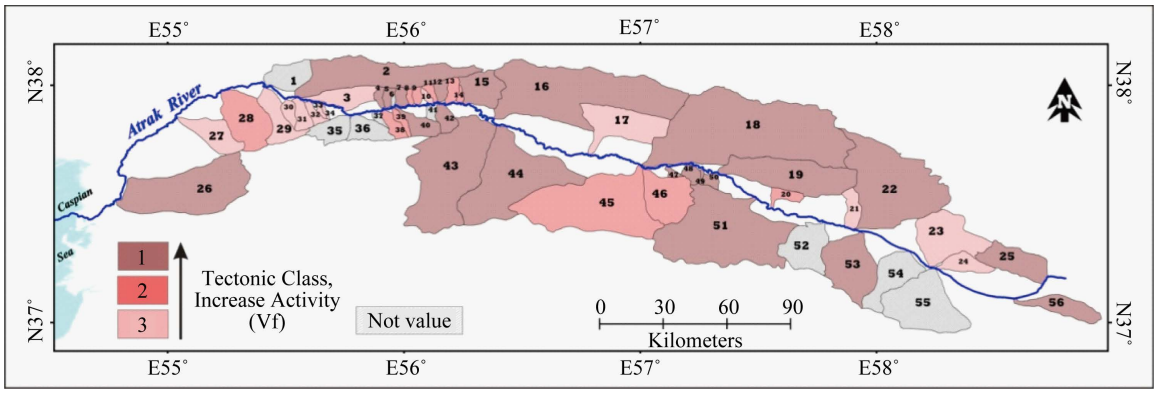
Figure 3. Physiographic-tectonic zoning map of Iran's sedimentary basins Iran, modified from [10]. Numbers in this figure are, 1: Zagros-East Taurus hinterland, 2: Persian Gulf-Mesopotamian foreland basin, 3: Makran accretionary prism, 4: Bashagard Mountains, 5: Jazmorian-Mashkel fore arc basin, 6: Shahsavaran-Soltan magmatic arc, 7: South Lut-South Helmand back arc basin, 8: East Iran Mountain belt, 9: West-Central Alborz and lesser Caucasus hinterland, 10: Great Kavir-Northen Urmieh lake foreland basin, 11: South Great Kavirfold and thrust belt, 12: South Caspian-Black sea foreland basin, 13: Urmieh-Dokhtar Magmatic Arc, 14: Naien-Kerman retro arc foreland basin, 15: Sanandaj-Sirjanoverthrust belts, 16: East Alborz or Binalod hinterland, 17: Torbat-eam-Neyshabour retro arc foreland basin, 18: Kope Dagh hinterland, 19: South Caspian remnant basin, 20: Maiamay-Taibad Inverted back arc basin, 21: Khaf-Kavir Plain Magmatic Arc, 22: Lut Plain-Gonabad back arc basin, 23: Tabas hinterland, 24:Yazd-Khour Piggy back basin. The study area is shown in the black rectangle.

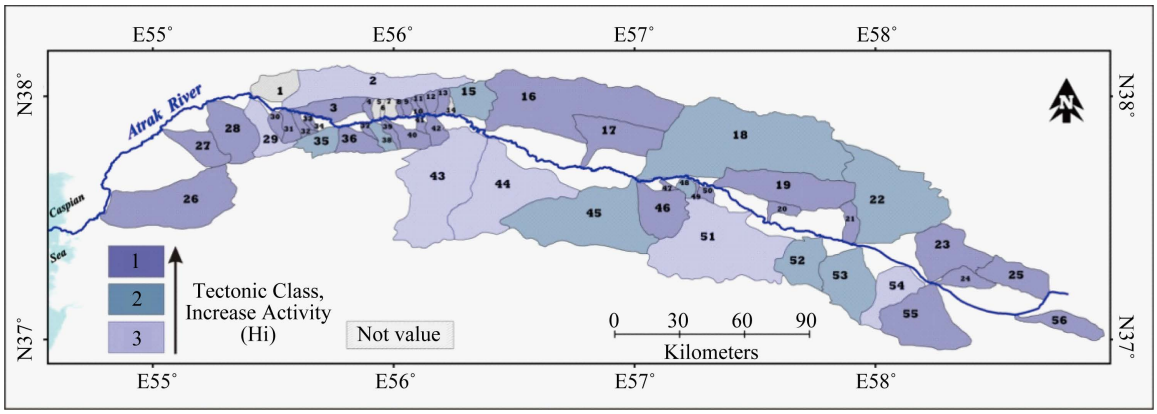
Table 1. Range of geomorphic indices, based on [25].

Geomorphic index	Class 1	Class 2	Class 3
Vf	Vf < 0.3	0.3 < Vf < 1	Vf > 1
J	J < 1.1	1.1 < J < 1.5	J > 1.5
Bs	Bs > 4	3 < Bs < 4	Bs < 3
Af	Af < 35 or Af > 63	57 < Af < 65 or 35 < Af < 43	43 < Af < 57
Sl	Sl > 500	300 < Sl < 500	Sl < 300
Hi	Hi > 0.5	0.4 < Hi < 0.5	Hi < 0.4


E55°
E56°
E57°
E58°
N38°
N37°
Atrak River
Caspian Sea
1
2
3
Tectonic Class,
Increase Activity
(Bs)
0 30 60 90
Kilometers


E55°
E56°
E57°
E58°
N38°
N37°
Atrak River
Caspian Sea
1
2
3
Tectonic Class,
Increase Activity
(AF)
0 30 60 90
Kilometers


E55°
E56°
E57°
E58°
N38°
N37°
Atrak River
Caspian Sea
1
2
3
Tectonic Class,
Increase Activity
(Vf)
Not value
0 30 60 90
Kilometers


E55°
E56°
E57°
E58°
N38°
N37°
Atrak River
Caspian Sea
1
2
3
Tectonic Class,
Increase Activity
(Hi)
Not value
0 30 60 90
Kilometers

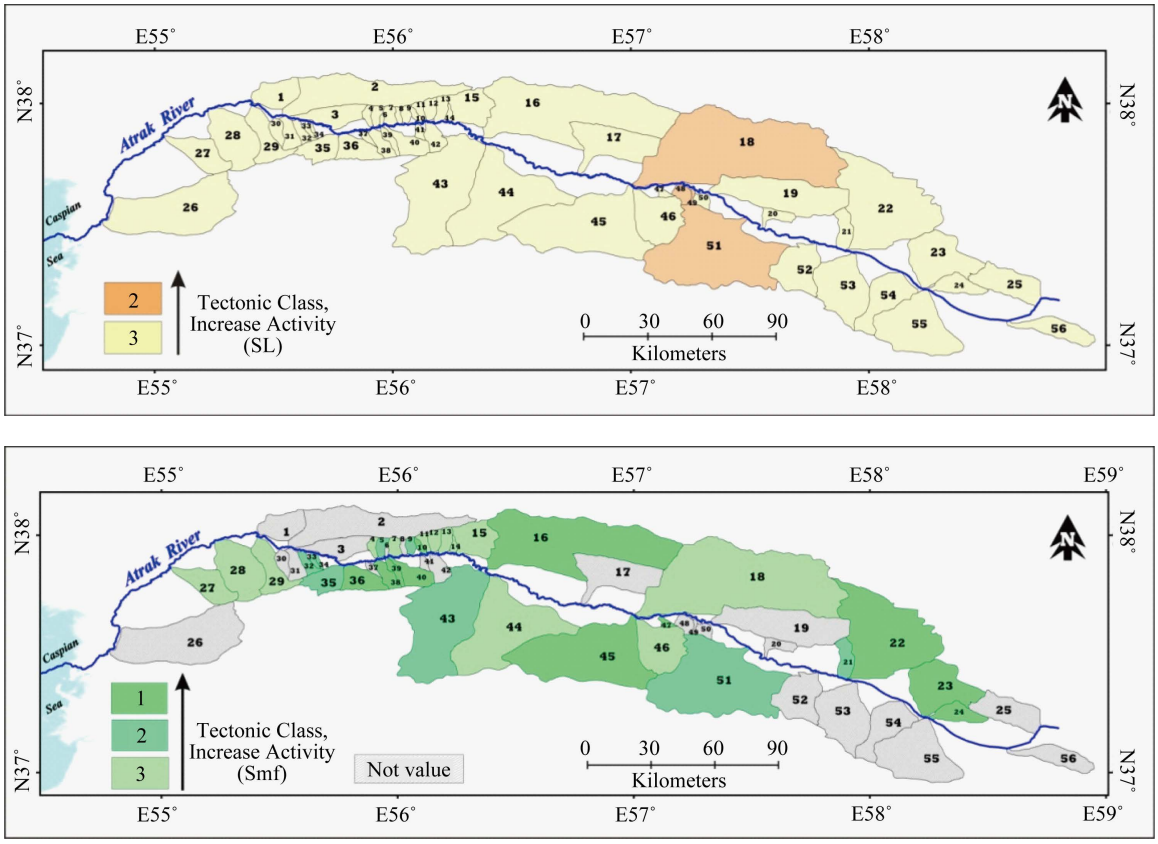


Figure 4. Distribution of six indices and classification of them into three classes.

geomorphic indices [42]-[47]. This study tried to evaluate tectonics in a wider area, using a number of geomorphologic parameters. The average of the six measured geomorphic indices (Iat) was used to evaluate the distribution of relative tectonic activity in the study area. The values of the index were divided into four classes to define the degree of active tectonics: 1—very high ($1.0 \leq Iat < 1.5$); 2—high ($1.5 \leq Iat < 2.0$); 3—moderate ($2.0 \leq Iat < 2.5$); and 4—low($2.5 \leq Iat$).

The distribution of the four classes is shown in **Figure 4**. The values of the six geomorphic indices as well as Iat often change corresponding to the distribution of fault zones. Kope dagh, Ghochan, Kerivan, Esfraien and Chamanbid faults are the structural boundary that they have been changed in deformational history of study area. In study area, the low class of Iat is mainly in the sub-basins of 1, 14, 29 & 31 while the other parts of the study area has moderate active tectonics. **Table 2** shows the result of the classification for each sub-basin.

4. Conclusions

Atrak River, north east Iran is a quaternary tectonically active region. The values of SL, Hi, and Bs were found to be high along major faults and folds. The values of Af show widespread drainage-basin asymmetry related to the tectonic tilting. The values of J suggest that mountain fronts are tectonically active, and the values of Vf show that many valleys are narrow and deep, suggesting a high rate of incision associated with tectonic uplift.

About the whole of the study area has Iat values of classes 2 and 3, indicating moderately to highly active tectonics. Class 2 of Iat, indicative of highly active tectonics, occurs mainly along the fault zone. These classes also correspond well to the areas with prominent scarps of tectonic origin, triangular facets, deformed alluvial fans, and deep narrow gorges.

Acknowledgements

This work has funded by the Department of geology, Islamic Azad University, Science and Research branch,

Table 2. Values of Lat.

Basin	Bs Tectonic Class	AF Tectonic Class	T Tectonic Class	Vf Tectonic Class	Hi Tectonic Class	SL Tectonic Class	Smf Tectonic Class	Iat Detail of Average	Iat Tectonic Class
1	3	3	3	_	_	3	_	3.00	3 (Low Activity)
2	1	2	3	1	3	3	_	2.17	2 (Moderate Activity)
3	3	1	3	3	1	3	_	2.33	2
4	3	3	3	1	1	3	3	2.43	2
5	3	3	2	1	_	3	2	2.33	2
6	2	2	2	_	_	3	_	2.25	2
7	3	1	2	1	_	3	3	2.17	2
8	2	3	2	2	1	3	_	2.17	2
9	3	1	1	2	1	3	2	1.86	2
10	2	2	3	3	1	3	1	2.14	2
11	3	1	1	2	1	3	3	2.00	2
12	3	2	1	1	1	3	3	2.00	2
13	3	3	2	2	1	3	3	2.43	2
14	3	3	2	2	_	3	3	2.67	3
15	3	2	1	1	2	3	3	2.14	2
16	3	1	1	1	1	3	1	1.57	2
17	3	1	2	3	1	3	_	2.17	2
18	3	1	2	1	2	2	3	2.00	2
19	2	2	2	1	1	3	_	1.83	2
20	3	1	2	2	1	3	_	2.00	2
21	2	3	2	3	1	3	2	2.29	2
22	3	1	1	1	2	3	1	1.71	2
23	3	3	3	3	1	3	1	2.43	2
24	3	3	2	3	1	3	1	2.29	2
25	3	3	3	1	1	3	_	2.33	2
26	3	1	1	1	1	3	_	1.67	2
27	3	2	1	3	1	3	3	2.29	2
28	3	3	2	2	1	3	3	2.43	2
29	3	2	2	3	3	3	3	2.71	3
30	3	2	2	3	1	3	_	2.33	2
31	3	3	2	3	1	3	_	2.50	3
32	3	1	2	3	1	3	2	2.14	2
33	2	1	1	3	1	3	2	1.86	2
34	1	2	2	3	1	3	2	2.00	2
35	3	1	2	_	2	3	2	2.17	2
36	3	1	1	_	1	3	1	1.67	2
37	2	1	1	_	1	3	_	1.60	2

Continued

38	3	1	1	2	2	3	1	1.86	2
39	1	3	2	2	1	3	1	1.86	2
40	3	2	2	1	1	3	1	1.86	2
41	3	2	3	_	1	3	_	2.40	2
42	3	3	2	1	1	3	_	2.17	2
43	3	1	2	1	3	3	2	2.14	2
44	3	2	1	1	3	3	3	2.29	2
45	3	1	1	2	2	3	1	1.86	2
46	3	3	2	2	1	3	3	2.43	2
47	3	2	2	1	1	3	1	1.86	2
48	3	2	2	1	2	2	_	2.00	2
49	2	3	2	1	1	2	_	1.83	2
50	3	2	2	1	1	3	_	2.00	2
51	3	1	3	1	3	2	2	2.14	2
52	3	2	2	_	2	3	_	2.40	2
53	3	3	2	1	2	3	_	2.33	2
54	3	1	1	_	3	3	_	2.20	2
55	3	3	2	_	1	3	_	2.40	2
56	2	2	3	1	1	3	_	2.00	2

Iat classification: 1 (High Activity), 2 (Moderate Activity), 3 (Low Activity).

Tehran, Iran. Also, Special thanks to vice-president for research in Science and Research branch, Tehran.

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