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Correlation between Seismic Activity and Tectonic Elements in Nineveh Governorate

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ABSTRACT

A computer file of earthquakes that have been recorded in Mosul Seismological Observatory and other Iraqi Observatories, were used to determine the seismic activity, location of epicenters and magnitude of earthquakes on the Richter scale. This information is used in conjunction with the analysis of geological and geomorphological features using Landsat TM imagery. These data were utilized to draw a seismotectonic map for the Nineveh Governorate, showing the relationship between earthquake epicenters and geological features.

This map is used to provide locations of earthquake risk throughout the study area. The main area of activity comprises most of the boundaries of major geological folds, faults, and location of major linear geomorphic lineaments. Both in the north eastern and south western parts of Mosul city have shown local moderately active zones, which is probably related to the major NE-SW geomorphic lineament. The regularity of the other lineament directions confirms the regional nature of the strike slip fault systems in the basement blocks of the studied region.

العلاقة المتبادلة بين النشاط الزلزالي والمظاهر التكتونية في محافظة نينوى

الملخص

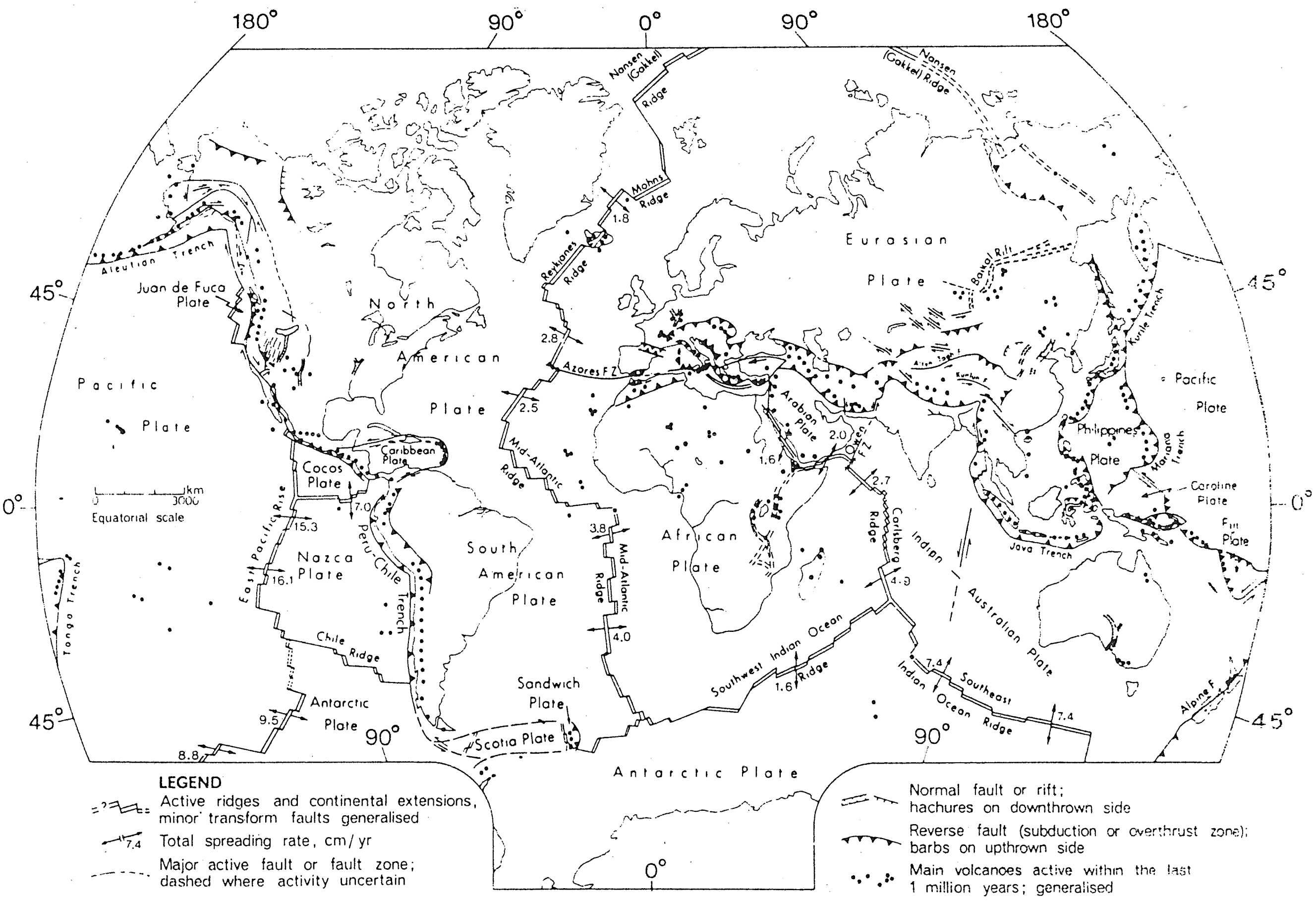
تم استخدام الملف الحاسوبي للهزات الارضية الماخوذة من تسجيلات مرصد الموصل الزلزالي والمعلومات المستلة من الملفة العراقية وذلك لتحديد مقدار النشاط الزلزالي، مساقط بؤر الهزات الارضية ومقاديرها حسب مقياس ريختير. تم ربط هذه المعلومات عن طريق تحليل البنية الجيولوجية ومظاهر الاشكال الجيومورفولوجية وذلك باستخدام مرئيات راسم الخرائط الموضوعي للقمر الاصطناعي لاندسات. استخدمت هذه المعلومات في اعداد خارطة محافظة نينوى الزلزالية والتكتونية، وذلك لإيضاح العلاقة بين مساقط البؤر الزلزالية و المظاهر الجيولوجية.

استخدمت هذه الخارطة في تحديد مواقع الخطر الزلزالي عبر منطقة الدراسة والتي شملت معظم انطقة حدود التراكيب الجيولوجية الرئيسية، إلى جانب مواقع اتجاهات مظاهر الخطيات المستقيمة. أظهرت الخارطة نطاق متوسط الشدة الزلزالية في شمال شرق وجنوب غرب مدينة الموصل، يعتقد بارتباطه مع نظام الخطيات الرئيسي ذو الاتجاه السائد شمال شرق-جنوب غرب. ان انتظام اتجاهات

المظاهر الخطية الأخرى يؤكد صحة طبيعة حركة نظام الصدوع المضربية المنتشرة في بنيـــة صـــخور القاعدة في عموم منطقة الدراسة.

INTRODUCTION

Earthquakes generally occur within well defined areas of the world, on which there is a striking pattern of continuous belts of activity (Selby, 1985). Modern theories of the structure of the earth identify these belts as the boundaries of mobile plates (Fig.1). Movement of one plate with respect to another causes stress and deformation at the boundary. The rocks accumulate strain which is periodically released by the failure or breaking of large blocks of crust, generating earthquakes.



GLOBAL TECTONIC AND VOLCANIC ACTIVITY OF THE LAST ONE MILLION YEARS

Fig. 1: Global tectonic and volcanic activity of the last one million years after (Selby, 1985).

In this study a part of the Stable and Unstable Shelf of NW of Iraq has been analyzed morphotectonically using both remote sensing and seismological data (Fig. 2). The fundamental framework of the structure and stratigraphy of northern Iraq is strongly influenced by the positioning of the country within the main tectonic units of the Middle East (Abbas, 1984 and Al Kadhimi, 1996). The seismic activity is related to the geodynamic situation arising from the progression of continual plate collision between the Arabian Plate and the Turkish and Iranian plates (Eurasian Plate) (Daly, 1989) (Fig.1). Studies on historical seismic activity (Al Sinawi and Ghalib, 1975) have shown a general association of epicentral locations with geological structure and tectonics of the country. Since our concern in this study is the Nineveh Governorate, we will thus focus our attention on this particular part of Iraq.

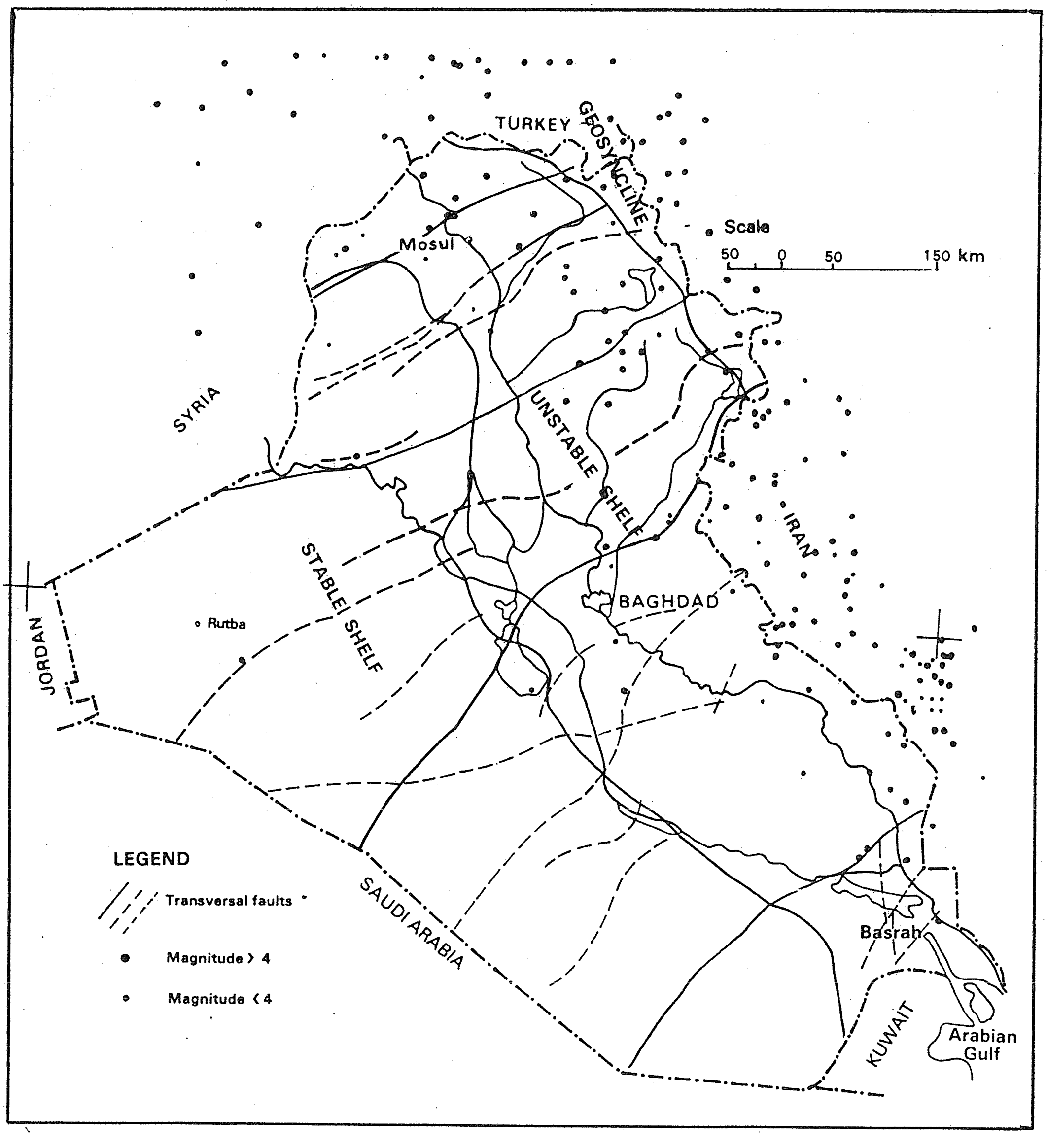


Fig. 2: Earthquake epicenter distribution map of Iraq. (after Abbas, 1984).

SEISMOLOGICAL AND REMOTE SENSING DATA

Earthquake epicenter distribution map of the Nineveh Governorate has been drawn (Fig. 3) using the available recording data from the Mosul Seismological Observatory (Table 1). These data has been utilized to determine the seismic activity, location of epicenters and magnitude of earthquakes (on the Richter scale) for the studied region. Data from computer files of the other Iraqi Observatories were also utilized (Table 2). Evidently, the highest recorded magnitude in the studied region from (1913 till 1988) is 5.9 degrees on the Richter scale, while the lowest recorded magnitude is 2.6 degrees.

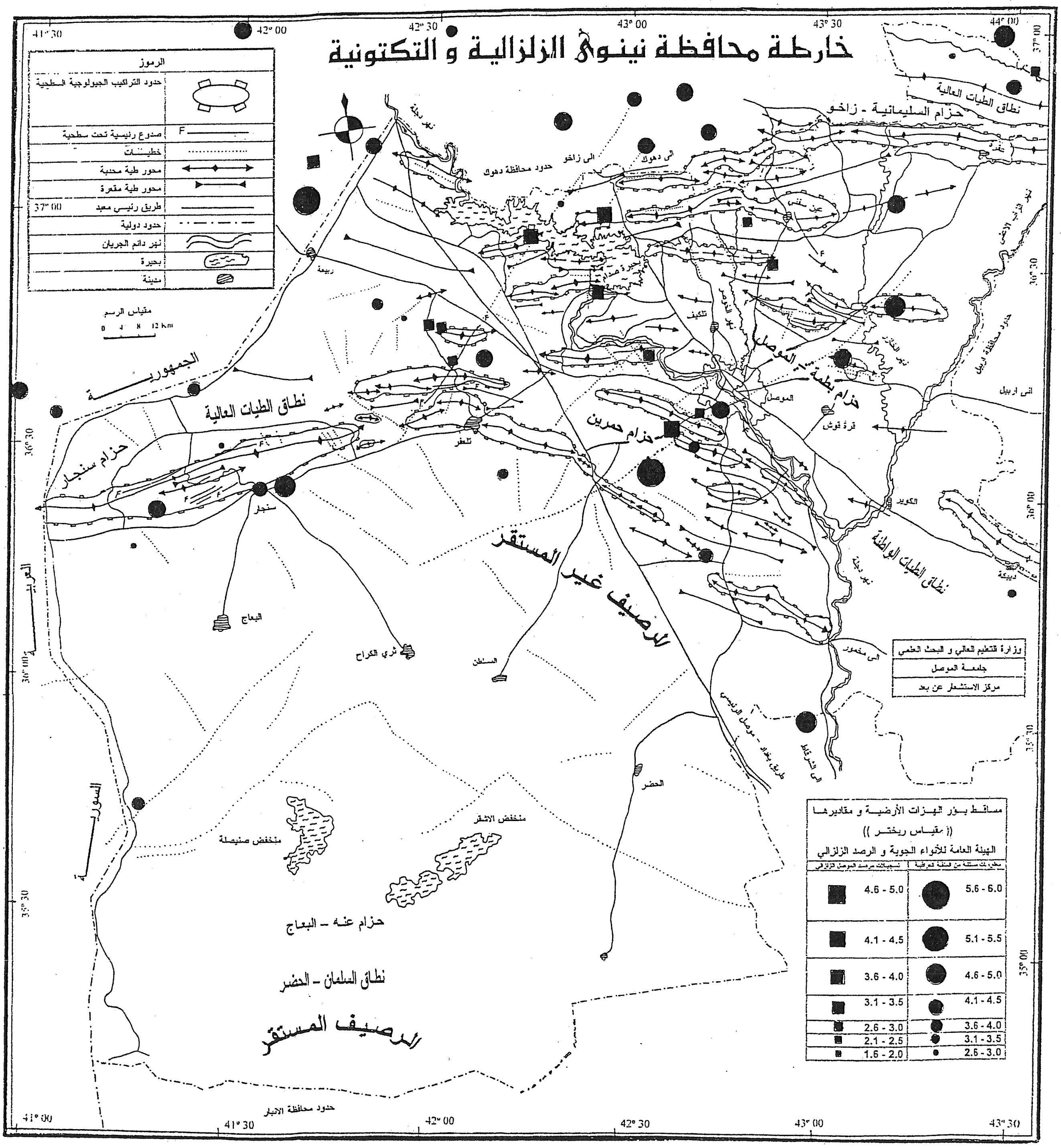


Fig. 3: Seismic and tectonic map of the Nineveh Governorate.

Table 1: Earthquakes recorded in Mosul Seismological Observatory.

Date of Earthquake	Magnitude	Direction from (MSL) in degree
14-3-1985	3.2	(- 53.0)
14-5-1985	2.6	(292)
28-11-1985	3.1	(-71)
26-4-1986	3.2	(-73)
26-11-1987	3.4	(53)
6-2-1988	2.9	(170)
8-7-1988	3.6	(72)
9-7-1988	3.3	(55)
6-8-1988	3.1	(-70)

Table 2. Earthquakes taken from Iraqi Observatories.

Date of Earthquake	(Latitude and Longitude)	Magnitude
1913	36.90-42.10	5.6
1916	36.30-43.10	4.5
1923	36.30-41.90	5.3
1924	36.90-43.20	4.5
1930	37.00-44.00	5.4
1931	36.47-43.60	5.0
1931	35.60-43.20	5.0
1935	36.50-42.50	4.8
1940	36.90-43.0	4.5
1940	37.00-43.00	4.6
1941	36.00-41.80	4.5
1944	37.30-42.8	4.6
1944	36.25-42.89	5.9
1945	36.30-41.98	4.0
1950	37.00-42.30	4.7
1960	36.60-41.30	4.6
1961	36.79-42.77	4.0
1962	36.30-41.60	4.2
1963	36.25-42.50	4.0
1967	35.84-44.08	3.0
1968	37.00-43.13	5.0
1969	36.65-43.64	4.5
1971	36.36-43.46	4.6
1971	36.09-43.95	3.0
1974	36.41-41.79	3.0
1974	36.63-42.30	2.8
1975	36.24-41.53	3.0
1984	36.24-43.03	3.9
1986	32.18-42.35	3.1

This information is used in conjunction with the analysis of geologic and geomorphic features using Landsat TM imagery, which is available at the Remote Sensing Center, in Mosul University (Table 3).

Table 3. Landsat TM imagery used in this study.

Image product format	Bands	Date
False color composite	2,4,7	6/4/1988
Infrared Black and White	5,7	7/3/1990
Normal color composite	1,2,3	10/1/2004

Complete coverage of the Nineveh Governorate by the Landsat imagery has been analyzed, to determine major geological features (Fold, faults and lineaments). In general, geological features were most readily observed on the black and white and color composite prints of the Landsat imagery. The most positive use of this imagery has been for the mapping of lineaments. The lineaments are reflections of structural, seismotectonic, and geomorphic features (Selby, 1985).

In general, known geological features, such as large anticlinal structures, major lithological boundaries, can be identified by the comparison with the existing (1:250,000) geological map produced by the Iraqi Geological Survey (Geosurv., 1995). Recognition of detailed geological features in Landsat TM imagery was often impossible at this scale, but the only significant new geologically important data, to be obtained from the images, was that relating to lineament studies and therefore only this aspect is discussed below.

METHODOLOGY

Landsat TM imagery proved particularly useful for revealing lineaments with in the study area. Some of these structures were known or suspected from ground studies, but the majority was revealed for the first time during the Landsat investigations (Fig. 3).

While classifing the lineamints, the authors have taken into consideration both physical and genetic parameters. On the basis of physical appearance, thus, Lineaments have been divided into:

1. **Curvilinears**- which could represent various fold closures and or erosional drainage characters ;
2. **Linears** – which could represent fracture zone and formational boundaries. Some linear features which do not fall into the above category, yet are well defined on the image, perhaps represent new local faults.

These lineaments have further been classified as major, intermediate and minor depending on their length of (30) Km or more, (30 to 5 Km) and less than (5) Km respectively.

The linear and curvilinear lineaments shown on (Fig. 3) can be interpreted using relatively standard photogeologic or geomorphic analysis such as has been done for many years in interpreting data from aerial photographs (Lillesand and Kiefer, 1994). Most of the major lineaments observed are undoubtedly related to the geodynamic situation arising from the progression of continual plate collision between the two major crustal plates, the Arabian Plate and the Eurasian Plate since the Mesozoic. This plate boundary has been subjected to a complex pattern of regional compression, extension and transcurrent displacements, collectively referred to as the Alpine Orogeny (Numan, 2001; and Al-Jawadi, 1998).

The major lineaments observed in the Landsat images are almost entirely confined to the Basement and covering strata. Many of the major lineaments are known faults predominantly oriented in an east–west, to northwest-southeast directions. The second set of lineaments striking in northeast-southwest direction, is visible in the high and low anticlinal folds of the Bashiqa, Ain Safra, Maqlub, Alan and Atshan which correspond to these mapped lineaments and major valleys (i.e main Ajij Valley , for example). Most of the minor lineaments are predominantly parallel to the major and intermediate lineaments, are contrasts either between lithologic boundaries or small new local fault systems (Fig. 3).

From reviewing the geological features, such as, folds, faults, and lineaments, it was found that the trend of geological structures are parallel to the trends of the structures of Zagros-Touros Belt, and the location of earthquake epicenters are approximately parallel to the axes of the major geological features (Fig. 3). The forces, which have formed the geological structures along the folded belt zone in Nineveh Governorate, are still active causing stress and strain accumulation and deformation in this vicinity. This information should be available for local authorities to consult when preparing their district and regional planning schemes. The Mosul City Council must use such information to avoid building across these hazards geological features. However the hazard associated with known fault movement caused by earthquakes can be reduced in the new development area (Al-Daghastani, 1998, Bisci and Dramis, 1992).

CONCLUSION

The main conclusions that may be drawn from this map are:

1. Generally, the seismic magnitude of the Nineveh Governorate is intermediate, in the range of (2.6 to 5.9) degrees on the Richter scale for the last ninety years, and the depth of seismic activity is shallow.
2. No major earthquakes are noticed south of the Folded Belt Zone (i.e the northern part of the Stable Shelf).
3. Scattered activity is found else where, and have shown a general association of epicentral locations with major geological structures.
4. The major geomorphic lineament that trends NE-SW, across the elevated anticlinal structures of Bashiqa and Ain Safra to the northeast of Mosul city and Atshan and Shaikh Ibrahim anticlines to the southwest, is the well expressed effect by seismic activity in the study area. This lineament, some of (60) km long can probably induce large earthquakes in this vicinity.
5. This seismic and tectonic activity map (Fig. 3) can be regarded as a database, in the improvement of the modern structural concepts, and in the distribution of the earthquake epicenter in this vicinity, which can greatly reduce the severity of the consequences on the community.

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