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Evaporites of the Mediterranean Tethys and Paratethys Neogene; application of results of the IGCP No. 25; part 3

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Abstract

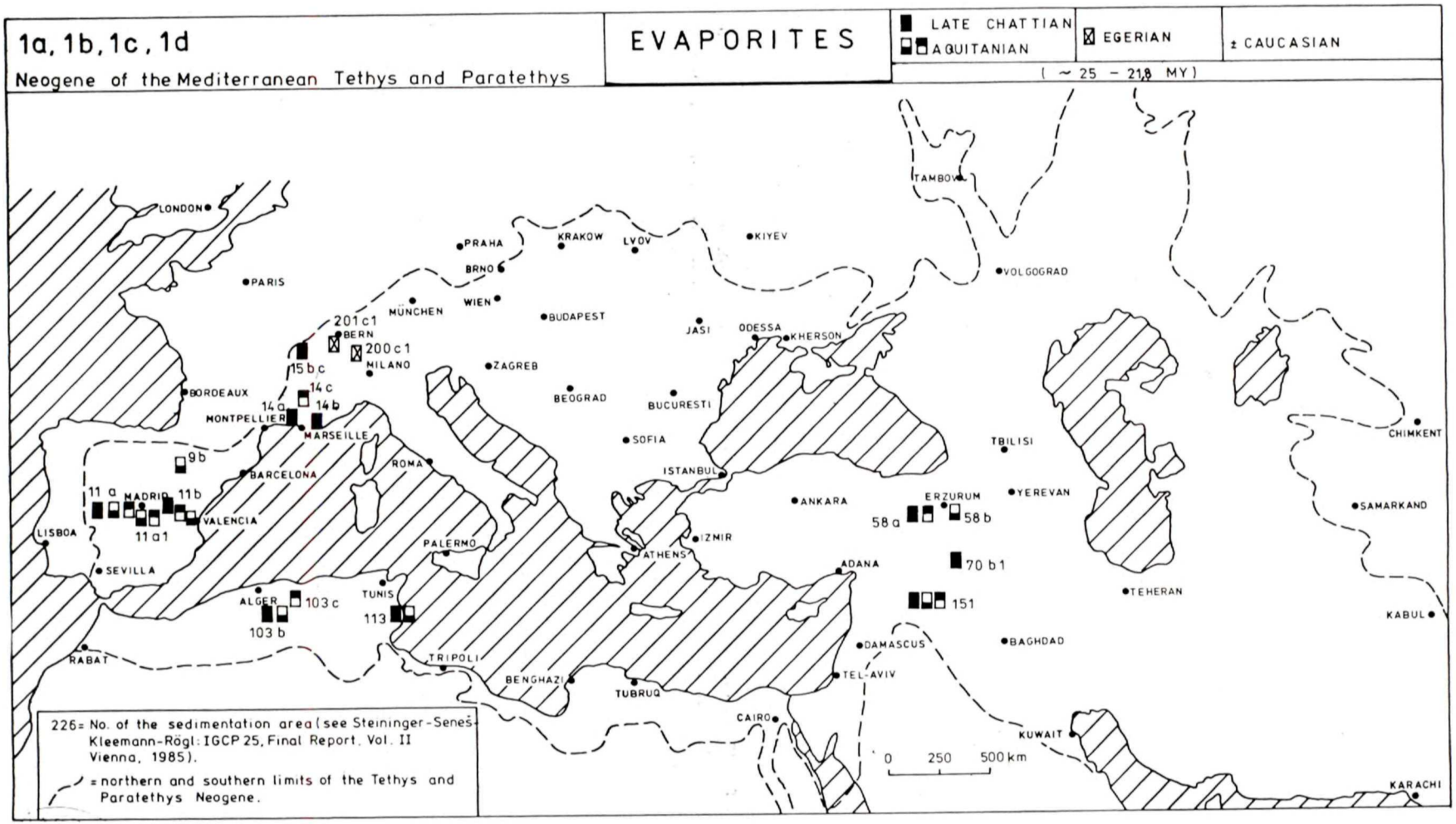
The presented third contribution of the author's series is dealing with the space and time distribution of Neogene evaporite deposits in an extensive intercontinental area between the Atlantic and Indopacific regions. In the text and illustrations presented analysis provides indispensable data for an exhaustive, i. e. including climatic and dynamic-paleogeographic reconstruction of Europe, Northern Africa and Western Asia in the last 25 milion years.

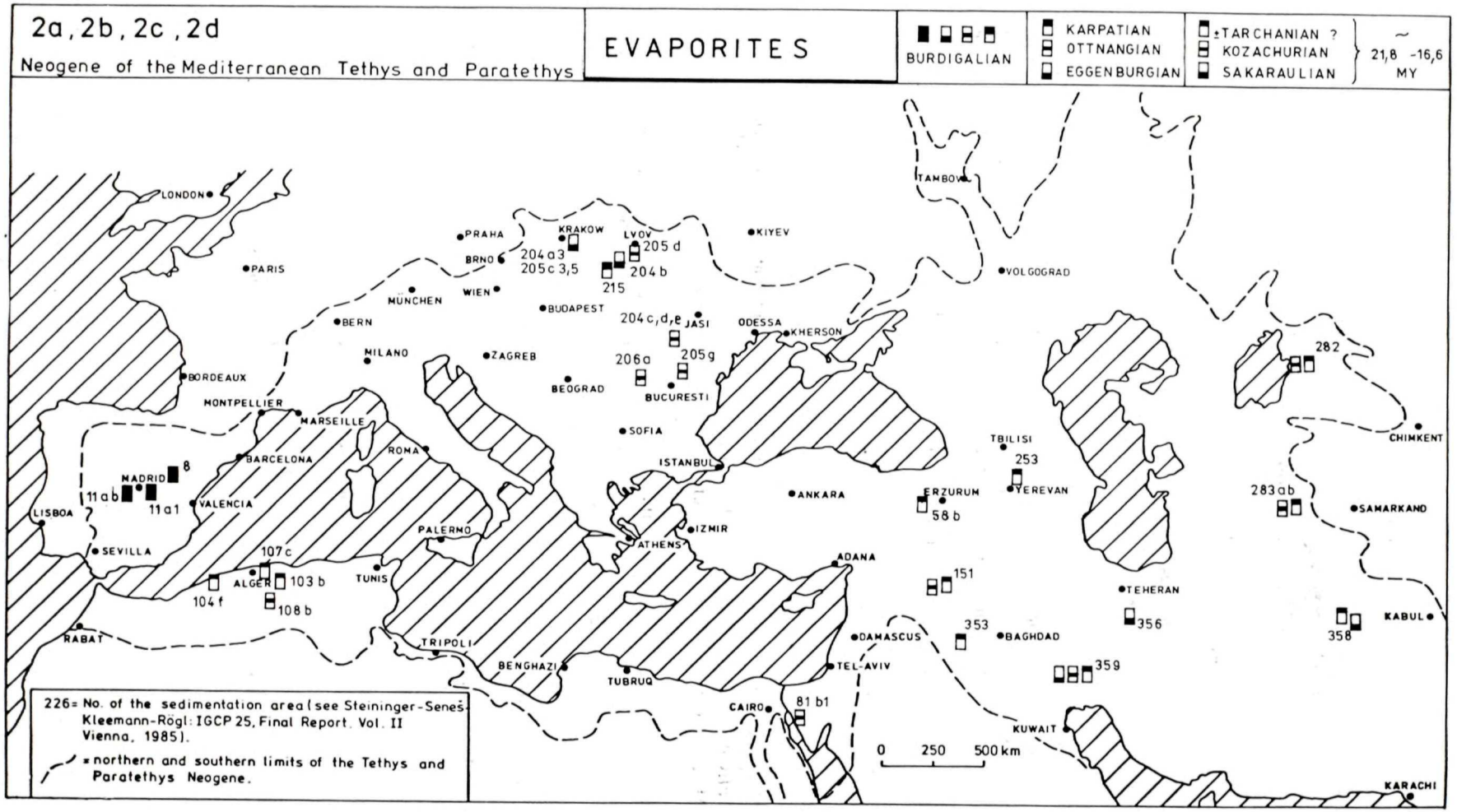
The maps attached to the Final Report of the Project No. 25 of the International Geological Correlation Programme (Steininger et al., 1985) contained only a schematic representation of evaporite occurrences in individual Neogene stages on the territory between the present Atlantic and Indopacific Oceans. Regarding their interregional paleogeographic and paleoclimatic importance, I consider it useful to summarize their more accurate stratigraphic and space classification. Thus I present in this series a graphical illustration of their distribution (Figs. 1—7). I have stressed especially their space distribution in late Middle Badenian in the Central Paratethys region and in Messinian in the Mediterranean Tethys region. In these two periods the interregional paleogeographic and paleoclimatic conditions were undoubtedly in one of these two regions most favourable for the evolution of territorially exceptionally extensive evaporite deposits.

I intend to present above all evaporites of hyperhaline marine and hyperhaline lacustrine origin. I did not deal with evaporites of terrestrial or fluviatile exsudational origin. Thus, in the following it is dealt above all with the deposits of NaCl, KCl, $KCl + MgCl_2 + 6H_2O$, $KCl + MgSO_4 + H_2O$, $CaSO_4$, $CaSO_4 \times 2H_2O$, $2CaSO_4 + MgSO_4 + K_2SO_4 + 2H_2O$, $MgSO_4 + H_2O$; rock salt, anhydrite and gypsum are undoubtedly the predominant ones.

From the illustrations it becomes evident that conditions favourable for evaporite formation were in Middle Badenian in the foredeep of the Carpathian Arc and in some parts of he north-eastern and eastern Intracarpathian region. This is indicated except by the aridity of climate in this time undoubtedly also by the signs of a regression of the Paratethys sea towards the Mediterranean Tethys and Indopacific Ocean, as well as by its becoming shallower. (According to the present knowledge this period corresponds approximately to the boundary Langhian/Severravalian.) It indicates probably one of the most significant uplift periods especially of the Carpathian arc, accompanied by movements of the surrounding regions. This uplift affected simultaneously the regions of Dinarides, Balcan and other Eastern and Central European mountain belts, and perhaps it could be connected with the "Leitha-phase" (Hámor, 1978). As a result of this, large, more or less isolated, neverthe-less with the disintegrating Middle Badenian sea still communicating lagoons could be formed especially in the forefield of these mountain belts. This was evidently the first pulse, first sign of a separation of Paratethys from the Neogene Tethys already in the end of Middle Badenian, i. e. approx. in the beginning of Serravallian. However, after this first sign of a partial separation the complete isolation of Paratethys from the Neogene Tethys was interrupted by one more marked marine transgression, in Upper Badenian. It flooded except the whole Central Paratethys territory probably also a considerable part of Eastern Paratethys, where it became apparent in Konkian due to an incresed salinity. (In the preceding Karagian time (stage), similar lagoon environments with evaporite formation came into existence in Eastern Europe and South-Western Asia as in Middle Badenian in Central Paratethys.)

As far as the enormous quantity of evaporites in


1a, 1b, 1c, 1d
Neogene of the Mediterranean Tethys and Paratethys
EVAPORITES
LATE CHATTIAN
AQUITANIAN
EGERIAN
± CAUCASIAN
(~ 25 - 21,8 MY)
LONDON
PARIS
PRAHA
BRNO
KRAKOW
LVOV
KIYEV
TAMBOV
VOLGOGRAD
MÜNCHEN
WIEN
BUDAPEST
JASI
ODESSA
KHERSON
201 c1
BERN
200 c1
MILANO
15 b c
ZAGREB
14 c
14 a
14 b
BORDEAUX
MONTPELLIER
MARSEILLE
BEOGRAD
BUCURESTI
SOFIA
TBILISI
CHIMKENT
9 b
BARCELONA
ROMA
ISTANBUL
11 a
MADRID
11 b
VALENCIA
11 a1
ANKARA
ERZURUM
YEREVAN
58 a
58 b
SAMARKAND
LISBOA
SEVILLA
PALERMO
IZMIR
ATHENS
ADANA
70 b1
ALGER
103 c
TUNIS
113
103 b
151
TEHERAN
KABUL
RABAT
TRIPOLI
BENGHAZI
TUBRUQ
DAMASCUS
BAGHDAD
TEL-AVIV
CAIRO
KUWAIT
0 250 500 km
KARACHI
226= No. of the sedimentation area (see Steininger-Senes-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.


2a, 2b, 2c, 2d
Neogene of the Mediterranean Tethys and Paratethys
EVAPORITES
BURDIGALIAN
KARPATIAN
OTTNANGIAN
EGGENBURGIAN
±TARCHANIAN ?
KOZACHURIAN
SAKARAULIAN
~ 21,8 -16,6 MY
LONDON
PARIS
PRAHA
BRNO
KRAKOW
LVOV
KIYEV
TAMBOV
VOLGOGRAD
MÜNCHEN
WIEN
BUDAPEST
BERN
MILANO
ZAGREB
BEOGRAD
BUCURESTI
JASI
ODESSA
KHERSON
BORDEAUX
MONTPELLIER
MARSEILLE
BARCELONA
ROMA
SOFIA
ISTANBUL
MADRID
VALENCIA
LISBOA
SEVILLA
PALERMO
ATHENS
IZMIR
ANKARA
ERZURUM
TBILISI
YEREVAN
CHIMKENT
SAMARKAND
ALGER
TUNIS
RABAT
TRIPOLI
BENGHAZI
TUBRUQ
CAIRO
ADANA
DAMASCUS
BAGHDAD
TEL-AVIV
TEHERAN
KUWAIT
KABUL
KARACHI
204 a 3
205 c 3,5
205 d
204 b
215
204 c,d,e
205 g
206 a
282
283 ab
8
11 a b
11 a 1
107 c
103 b
104 f
108 b
58 b
253
151
353
356
358
359
81 b1
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report. Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.

Messinian is concerned, these are connected above all with the extensive Mediterranean Tethys regions (Neogene Tethys relic of the Circummediterranean area). Geodynamic and paleogeographic controls on their formation are presently already sufficiently well explained, and thanks to the succesfull conclusion of the IGCP Project No. 96 they do not require further comments (Cita, 1982).

However, the concentration of evaporite occurrences in some parts of the broader Mediterranean region is interesting also in other Neogene periods. An analysis of their age and space distribution could provide valuable information for paleogeographic and geodynamic recontructions.

In the sedimentation areas of the Rhône Basin region, evaporites are predominant especially in Upper Chattian, namely toward north, up to Switzerland. Evaporite occurrences can be found in the Tajo-Guadiana and Madrid Basin almost in whole Miocene and Pliocene, from Tortonian or also in the extensive Duero Basin, and as far as Messinian is concerned, evaporites occur especially in regions lying nearer to the present Mediterranean Alboran as well as in Southern Balearic Basin (i. e. on the present Pyrenean Peninsula, in the Granada and Batic Basins area). Similarly frequent evaporite occurrences can be registered in the western part of the Mediterranean Tethys, south of the Alboran and Balearic Basins on the tectonically exceptionally complicated terrain of Northern Africa, above all in Algeria. Here the already in Burdigalian abundant evaporite occurrences became even more extensive in Langhian and especially from Tortonian on. From this time to the end of Messinian, evaporites were present also in the regions of Bizerte, Cap Bon, Golfe de Gabes, as well as in eastern and south-western Tunisia.

In Eastern Mediterranean region, especialy in North Red Sea Basin and in the Suez Basin, the scarcity of evaporites is particularly in Messinian not surprising (altitude difference to „Lago-Mare"). On the other hand, their occurrence is in this region very frequent from Langhian to the end of Serravalian. As for Near East, especially south of Caucasus, in the Mesopotamian, broader Caspian and Zagros regions, the formation of large deposits was concentrated in Upper Oligocene and Aquitanian, in Serravalian (or Karaganian) and in Tortonian. Occurrences on the boundary of Eggenburgian/Ottnangian, or Ottnangian/Karpatian in Central Paratethys, especially in the northern, eastern and southern part of the Carpathian foredeep, are not negligible.

The numerical and alphabetical denotations applied in the following list are connected with the geographic situation of the basins — see Seneš (1989), Steininger et al. (1985).

1. Late Chattian + Aquitanian = Egerian = ±Caucasian (25—21.8 MY)

1a. Late Chattian

11a — Tajo-Guadiana B., Fosa de Madrid, E; **11b** — Tajo-Guadiana B., E. Altomira (lower part of the „Upper Detrital Unit") E; **14a** — Province, Camarque-Golfe du Lyon (in "Complexe Oligocene de Camargue") F; **14b** — Province, La basse Durance a la mer (Gypse d'Aix) F; **15bc** — Lyon-Bas Dauphine-Vercors-Dombes-Bresse, F; **58a** — Erzincan-Cayirli, TR; **70b1** — Erzurum-Karayazi Area W. (Cigilgan Fm.) TR; **103b** — Bassin du Hodna, Region E. DZ; **113** — Plateau sous-marin de Kerkennah, Golfe de Gabes (in upper part of the "Lower Ketatna Fm.") TN; **151** — Syria (Midyat Fm.) SYR;

1b. Early Aquitanian

9b — Ebro Depr., Rioja-Baja-Navarra ("Yesos de Losarcos Fm.") E; **11a** — Tajo-Guadiana B., Fosa de Madrid (low. part of the "M_1—M_2 Gr.") E; **11a1** — Madrid B., (low. part of the "Evaporitic Unit") E; **11b** — Tajo-Guadiana B., E. Altomira (upp. part of the "Upper Detrical Unit") E; **58d** — Erzurum-Askale (base of the "Kemerkaya Fm.") TR; **103b** — Bassin du Hodna, Region E. DZ; **113** — Plateau sous-marin de Kerkennah Golfe de Gabes (in "Middle Ketatna Fm.") TN; **151** — Syria (lower part of the "Lower Fars Fm." ?) SYR;

1c. Late Aquitanian

11a — Tajo-Guadiana B., Fosa de Madrid (middle part of the M_1—M_2 Gr.) E; **11a1** — Madrid B., (middle-upp. part of the "Evaporitic Unit") E; **11b** — Tajo-Guadiana B., E. Altomira (lowermost part of the "Terminal Unit") E; **14c** — Province, Golfe Durancien, F; **58a** — Erzincan-Cayirli (Pülk-Engice Fm.) TR; **103c** — Hodna Oriental (Col de Tifelouine) DZ; **151** — Syria (middle part of the "Lower Fars Fm."?) SYR;

1d. Egerian (early)

200cl — Subalpine Molasse (Gypsmergel — late Chattian; see also 15bc) CH; **201cl** — Mittelländische Molasse (Gypsmergel — late Chattian; see also 15bc and 200cl) CH;

2. Burdigalian = Eggenburgian + Ottnangian + Karpatian = Sakaraulian + Kozachurian ± Tarchanian (~21,8—16,6 MY)

2a. Burdigalian in general

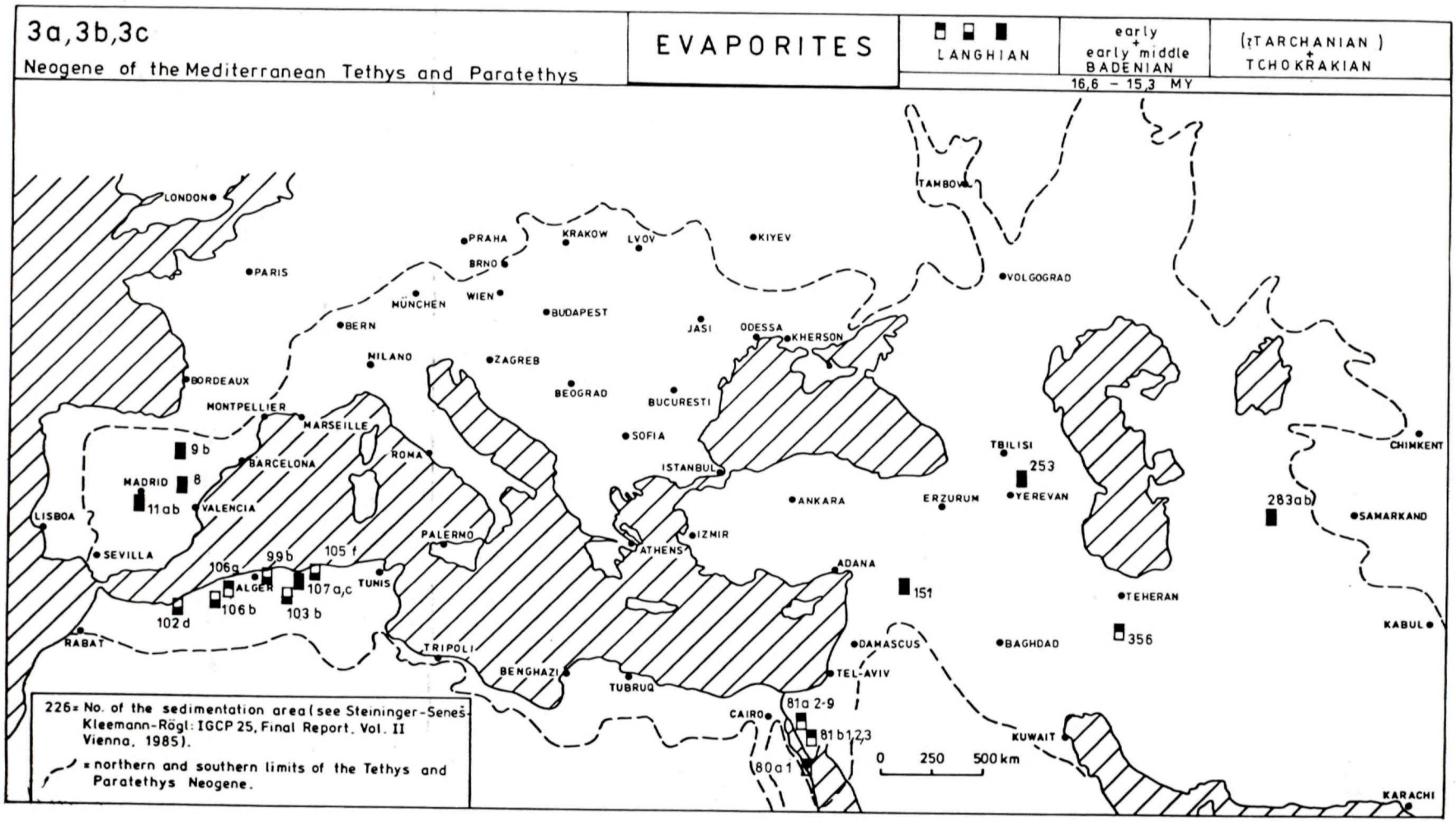
8 — Iberic Depr. (low. part of the "Catalayud") E; **11a1** — Madrid B., (upp. part of the "Evaporitic Fm." and low. part of the "Intermediate Unit") E; **11ab** — Tajo-Guadiana B., Fosa de Madrid, E. Altomira (low. part of the "Terminal Unit", upp. part of the "M_2 Gr.") E;

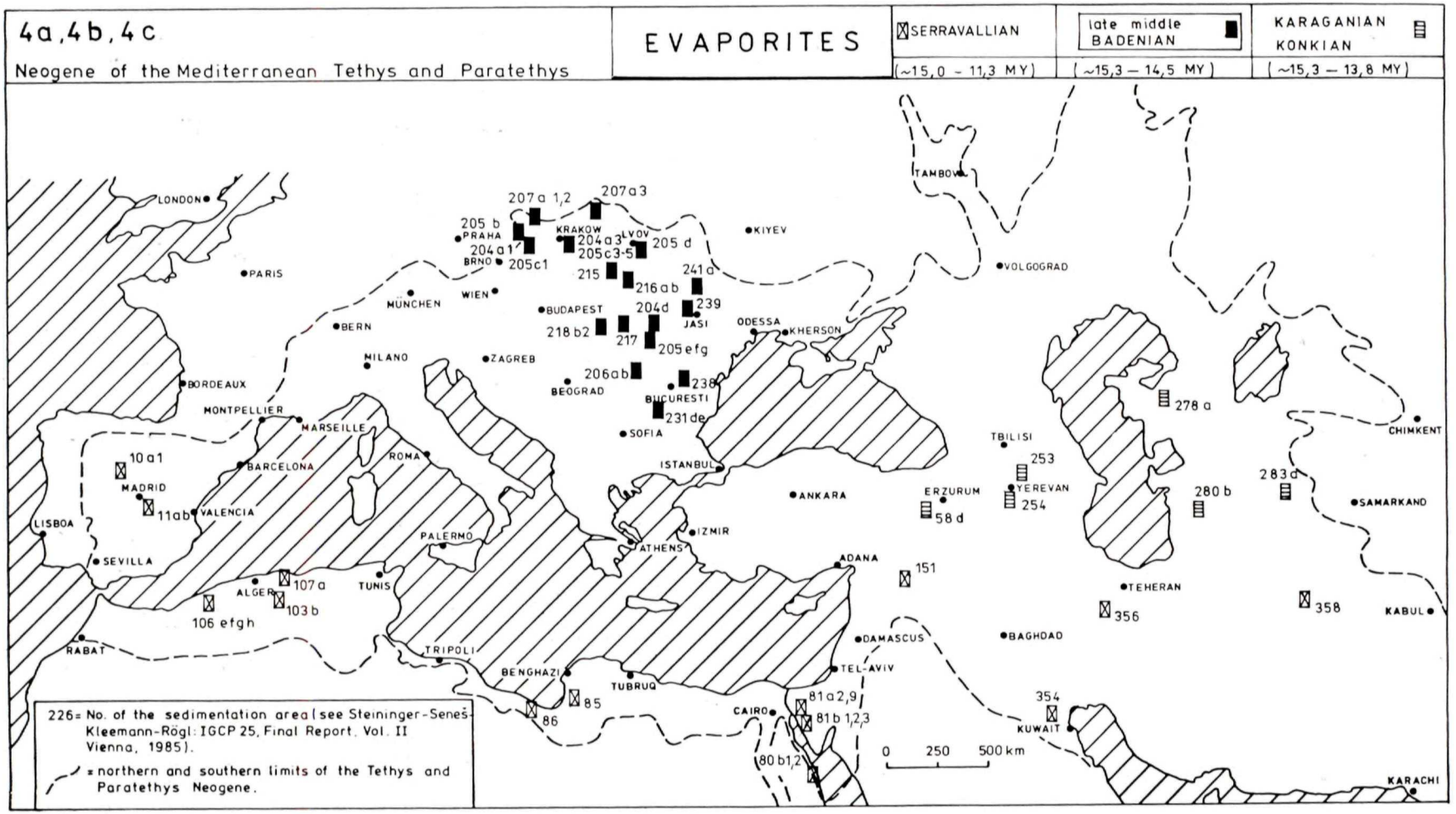
2b. Early Burdigalian (= Eggenburgian = ± Sakaraulian)

204a3/205c3,5 — Western — Eastern Carpathian Foredeep (base of the Modrych Mb.) PL; **204b** — Carpathian Flysh Zone in the USSR (Upper Krosno Fm.) SU; **356** — Qum B., Central Iran (Qum Fm. — upper part) IR; **358** — Albourz (low. "Red Fm.") IR; **359** — Zagros B. (midd.-upp. part? of the "Gachsaran Fm.") IR;

2c. Middle Burdigalian (= Ottnangian = ± Kozachurian)

81bl — Gulf of Suez B. (Nukhul Fm.) ET; **108b** — Bordure W. and SW. de l'Aures, DZ; **151** — Syria (upp. part of the "Lower Fars Fm."?) SYR; **204cd** — East Carpathian Flysh Zone — Marginal Folds, Tarcan Nappe etc. ("Salt Fm.", "Lower Gypsum Fm.") R; **205d** — Subcarpathian Miocene Foredeep (in Balitsh Fm.) SU; **205g** — Subcarpathian folded Neogene Foredeep, Dimbovita-Buzau Region ("Grey gypsum Fm.") R; **206a** — South Subcarpathian


3a, 3b, 3c
Neogene of the Mediterranean Tethys and Paratethys
EVAPORITES
LANGHIAN
early + early middle BADENIAN
(?TARCHANIAN) + TCHOKRAKIAN
16,6 – 15,3 MY
LONDON
PARIS
PRAHA
KRAKOW
LVOV
KIYEV
BRNO
MÜNCHEN
WIEN
BUDAPEST
BERN
JASI
ODESSA
KHERSON
TAMBOV
VOLGOGRAD
MILANO
ZAGREB
BORDEAUX
BEOGRAD
BUCURESTI
MONTPELLIER
MARSEILLE
SOFIA
ROMA
BARCELONA
ISTANBUL
TBILISI
CHIMKENT
MADRID
VALENCIA
ANKARA
ERZURUM
YEREVAN
SAMARKAND
LISBOA
PALERMO
IZMIR
ATHENS
SEVILLA
ADANA
TUNIS
ALGER
TEHERAN
RABAT
TRIPOLI
DAMASCUS
BAGHDAD
KABUL
BENGHAZI
TEL-AVIV
TUBRUQ
CAIRO
KUWAIT
KARACHI
9b
8
11ab
106g
99b
105f
107a,c
106b
103b
102d
151
356
253
283ab
81a 2-9
81b 1,2,3
80a 1
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.


4a,4b,4c
Neogene of the Mediterranean Tethys and Paratethys
EVAPORITES
SERRAVALLIAN
(~15,0 - 11,3 MY)
late middle BADENIAN
(~15,3 – 14,5 MY)
KARAGANIAN
KONKIAN
(~15,3 – 13,8 MY)
LONDON
PARIS
BORDEAUX
MONTPELLIER
MARSEILLE
BARCELONA
MADRID
VALENCIA
LISBOA
SEVILLA
RABAT
ALGER
TUNIS
TRIPOLI
BENGHAZI
TUBRUQ
CAIRO
PALERMO
ROMA
MILANO
BERN
MÜNCHEN
WIEN
PRAHA
BRNO
KRAKOW
LVOV
BUDAPEST
ZAGREB
BEOGRAD
SOFIA
BUCURESTI
ISTANBUL
ATHENS
IZMIR
ANKARA
ADANA
DAMASCUS
TEL-AVIV
BAGHDAD
KUWAIT
TAMBOV
VOLGOGRAD
KIYEV
ODESSA
KHERSON
JASI
TBILISI
YEREVAN
ERZURUM
TEHERAN
CHIMKENT
SAMARKAND
KABUL
KARACHI
10a1
11ab
107a
103b
106 efgh
85
86
207a 1,2
207a3
205 b
204a1
205c1
204a3
205c3-5
205 d
215
241a
216ab
239
204d
218b2
217
205efg
206ab
238
231de
58d
253
254
278 a
280 b
283d
151
356
358
354
81a2,9
81b 1,2,3
80b1,2
0 250 500 km
226= No. of the sedimentation area (see Steininger-Senes-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.

Foredeep, Getic Depr. E. ("Sarata gypsum") R; **282** — Central Kizil-Kum (low. part of the Agitminsk Gr.) SU; **283ab** — East Turkmenistan N. and S. part (in "Oncophora Bds.") SU; **359** — Zagros B. (low. part of the Mishan Fm.) IR;

2d. Late Burdigalian (= Karpatian = ± Tarkhanian?)

58b — Erzincan-Tercan (upp. part of the Vartik Fm.) TR; **103b** — Bassin du Hodna, Region E., DZ; **104f** — Dahra, DZ; **107c** — Soummam, M'Chedillah, DZ; **151** — Syria (low.) midd. boundary part of the "Fars FM.") SYR; **215** — East Slovakian B. (Solivar evaporitic Mb.) CS; **253** — Sevan, Shirak and Middle Araks Depr., Erevan Synclinorium (lowermost part of the "Gyps-saliferous Fm.") SU; **282** — Central Kizil-Kum (middle part of the Agitiminsk Fm.) SU; **283ab** — East Turkmenistan, N. and S. part (Sagadhinsk Gr.) SU; **353** — Mesopotamian B. (Dhiban anhydrit Fm.) IRQ; **358** — Central Albourz (in low. part of the "Middle Red Fm.") IR; **359** — Zagros B. (middle part of the "Mishan Fm.") IR;

3. Langhian = Early — early Middle Badenian = ± Tarkhanian (?) + Tchokrakian (16,6—15,3 MY)

3a. Langhian in general

8 — Iberic Depr. (middle part of the "Calatayud") E; **9b** — Ebro Depr., Rioja-Baja, Navarra (Yesos de Monteagudo Fm.) E; **11ab** — Tajo-Guadiana B., Fosa de Madrid, Altomira (lowermost part of the "M_3Gr.", middle part of the "Terminal Unit") E; **107ac** — Moyen Cheliff, Soummam, DZ; **151** — Syria, (low. part of the "Middle Fars Fm."?) SYR; **253** — Sevan, Shirak and Middle Araks Depr., Erevan Synclinorium (middle part of the "Gyps-saltferous Fm.") SU; **283ab** — East Turkmenistan, N. and S. part (uppermost part of the "Sagadzhin Gr.) SU;

3b. Early Langhian

99b/105f — Petite Kabylie (Collo, El Milia) DZ; **103b** — Hodna B., Region E., DZ; **102d** — Bordure S. des Beni Chougrane, DZ; **106b** — Plateau de St. Louis, DZ;

3c. Late Langhian

80a1 — North Red Sea B. (Belaym Fm.) ET; **81a2—9** — Gulf of Suez B. (Kareem and Belaym Fm.) ET; **81b1—3** — Gulf of Suez B. (Belaym Fm.) ET; **106g** — Zone axiale du Bas-Cheliff (Sondage BD-3) DZ; **356** — Qum B. (lowermost part of the "Upper Red Fm.") IR;

4a. Serravallian in general (Medit. Tethys, ~**15,0—11,3MY**)

10a1 — Duero B., W., Valladolid, Zamora ("Gypsoferous facies") E; **11ab** — Tajo-Guadiana B. (low.-midd. part of the "M_3'Gr.", middle part of the "Terminal Unit") E; **80b 1—2** — North Red Sea B., Egyptian Coastal B. (middle part of the "Zug el Bahar Gr.") ET; **81a2—9** — Gulf of Suez B. (South Gharib Fm.) ET; **81b1—3** — Gulf of Suez B. (South Gharib Fm., middle part of the "Ras Malaab Gr.") ET; **85** — Augila Depr. (base of the Sceleidina Fm.) LAR; **86** — Sirte B. (upp. part of the Marada Fm.) LAR; **103b** — Hodna B. (lowermost part of the "Fm. des marnes á boules jaunes") DZ; **106efgh** — Bas Cheliff, Bordure S. de Dahna, Zone axiale du Bas Cheliff, Bordure NW. de l'Ouarsenis ("facies Anasseur") DZ; **107a** — Moyen Cheliff, DZ; **151** — Syria (upp. part of the "Middle Fars Gr"?) SYR; **354** — Persian Gulf B. ("Lower Fars Fm.", Zahra Fm.) KWT; **356** — Qum B. (in low. part of the "Upper Red Fm.") IR; **358** — Central Albourz (middle part of the "Red Fm.") IR;

4b. Late Middle Badenian (Central Paratethys, ~ **15,3—14,5 MY)**

204a1/205c1 — Upper Silesia S. (base of the Bochnia Fm.) PL; **204a3/205c3—5** — Eastern Carpathian Foredeep (low. part of the Bochnia Fm.) PL; **204d** — East Carpathian Flysh Zone, Tarcan Nappe, Buzau-Dimbovita ("Evaporitic level') R; **205b** — Subcarpathian Miocene Foredeep ("Evaporites-Gypsum Hz.") CS; **205d** — Subcarpathian Miocene Foredeep (Tiras Fm.) SU; **205efg** — Subcarpathian folded Neogene Foredeep ("Evaporitic level") R; **206ab** — Subcarpathian Foredeep, Getic Depr. E., W. ("Evaporitic Hz", and in "Radiolarian clays") R; **207al, 2** — Upper Silesia, N. ("Evaporite Hz.") PL; **207a3** — Marginal Zone, Holy Cross Mts. ("Evaporite Hz.") PL; **215** — East Slovakian B. ("Evaporitic Fm.") CS; **216ab** — Zakarpatia, Maramures B. ("Evaporitic Hz.", "Solotvino Mb.") R, SU;**217a, b 1—4, c** — Transylvanian B. ("Evaporitic Hz.") R; **218b2** — Intra-Carpathian Depr. E., Mont Apuseni Region-Borod-Sylvania ("Evaporitic Hz.") R; **238** — Dacic B. ("Arenaceous Foram. Z.") R; **239** — W . part of E. European Plateau and Birland Depr. ("Evaporitic Fm.") R; **241a** — Moldavian Platform ("Tiras Hz.") SU; **231de** — Vidin Area of Lom Gulf, Lom Depr. ("Gypse Hz.") BG;

4c. Karaganian + Konkian (Eastern Paratethys, ~ **15,3—13,8 MY)**

58d — Erzurum-Askale (lower part of the "Örtü Kayalari Gr.") TR; **253** — Sevan, Shirak and Middle Araks Depr., Erevan Synklinorium (upp. part of the "Gyps-saltiferous Gr.") SU; **254** — Nachitchevan Depr., SU; **278a** — Southern Ustjurt ("Barnea Bd.") SU; **280 b** — West Turkmenistan, S. (base of the "Spaniodontella Bd.") SU; **283a** — East Turkmenistan, N. ("Sartagan Hz.") SU;

5. Tortonian = Pannonian + Early-Middle Pontian (CP) = Bessarabian + Chersonian + Maeotian + Early-Middle Pontian (EP) (~11,3—6,4 MY)

5a. Tortonian in general

8 — Iberic Depr. (low. part of the "Tortajada Fm.") E; **11ab** — Tajo-Guadiana B., Fosa de Madrid, Altomira (upp.part of the "M_3Gr.", upp. part of the "Terminal Unit") E; **80al, 2** —North Red Sea B., (upp. part of the "Zeit and Gharib Fm.") ET; **81abc** — Gulf of Suez B. ("Zeit and Sarbut El Gamal Fm.") ET; **106d** — Bassin du Bas Cheliff, DZ; **151** — Mesopotamian B. ("Lower Fars Fm.") SYR;

5b. Early Tortonian

80b1 — North Red Sea B., Egyptian Coastal Plain (uppermost part of Abu Dabbab Fm.) ET; **104c** — Bassin Littoral, Les Andalouses Oued Hammadi (the basal beds) DZ; **113** — Plateau sous-marin de Kerkennah, Golfe de Gabes (upp. part of the Beglia Fm.) TN;

5c. Middle Tortonian

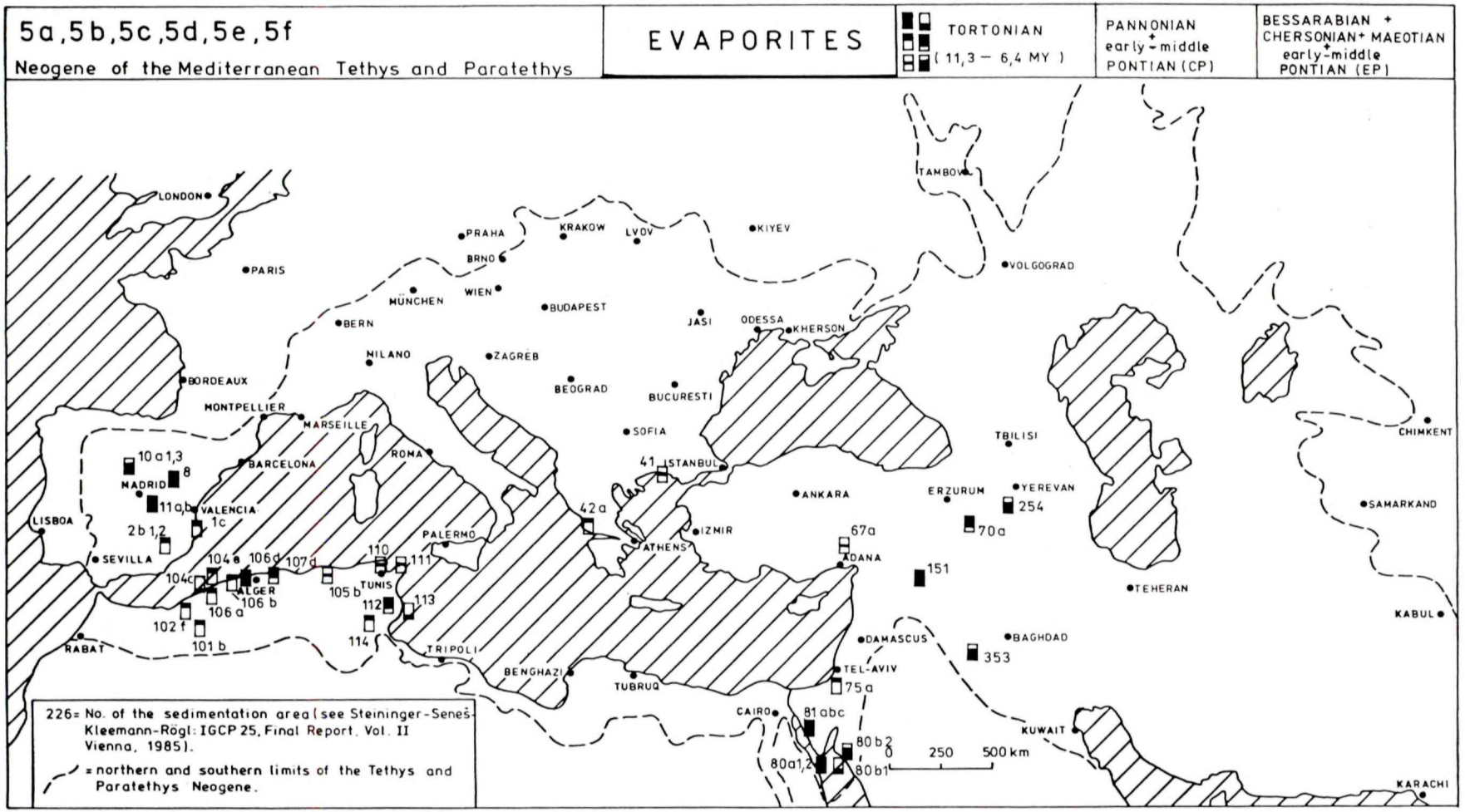
41 — Thracian Marginal B., Nestos River Delta ("Evaporitic Fm.") GR; **67a** — Adana B., Karaisali, TR; **105b** — Region d'Alger, DZ; **110** — Bizerte (Mellaha Evaporites, "Oved El Melah shale") TN; **111** — Cap Bon ("Gray shale with Gypsum") TN;

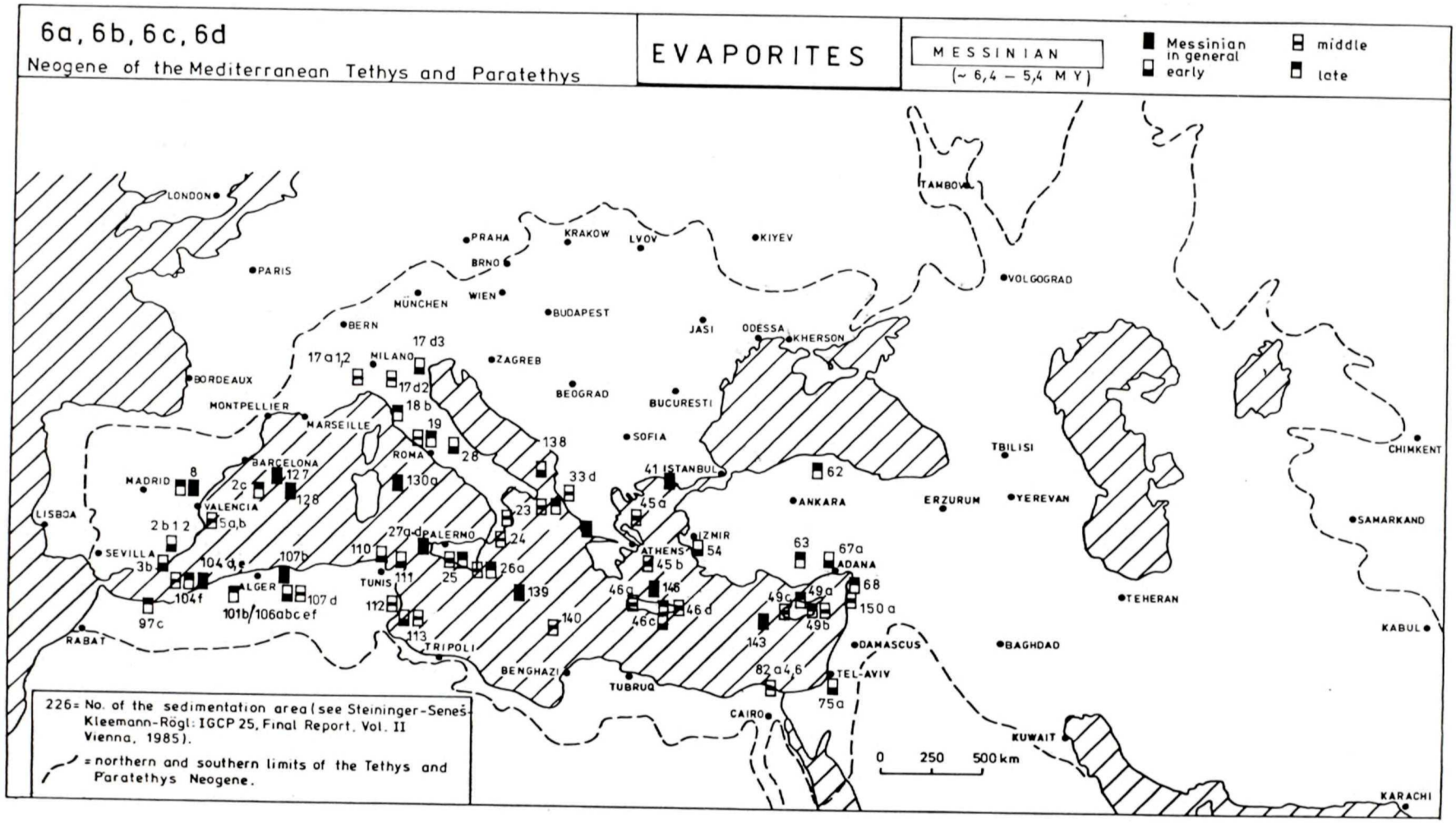
5d. Late Tortonian

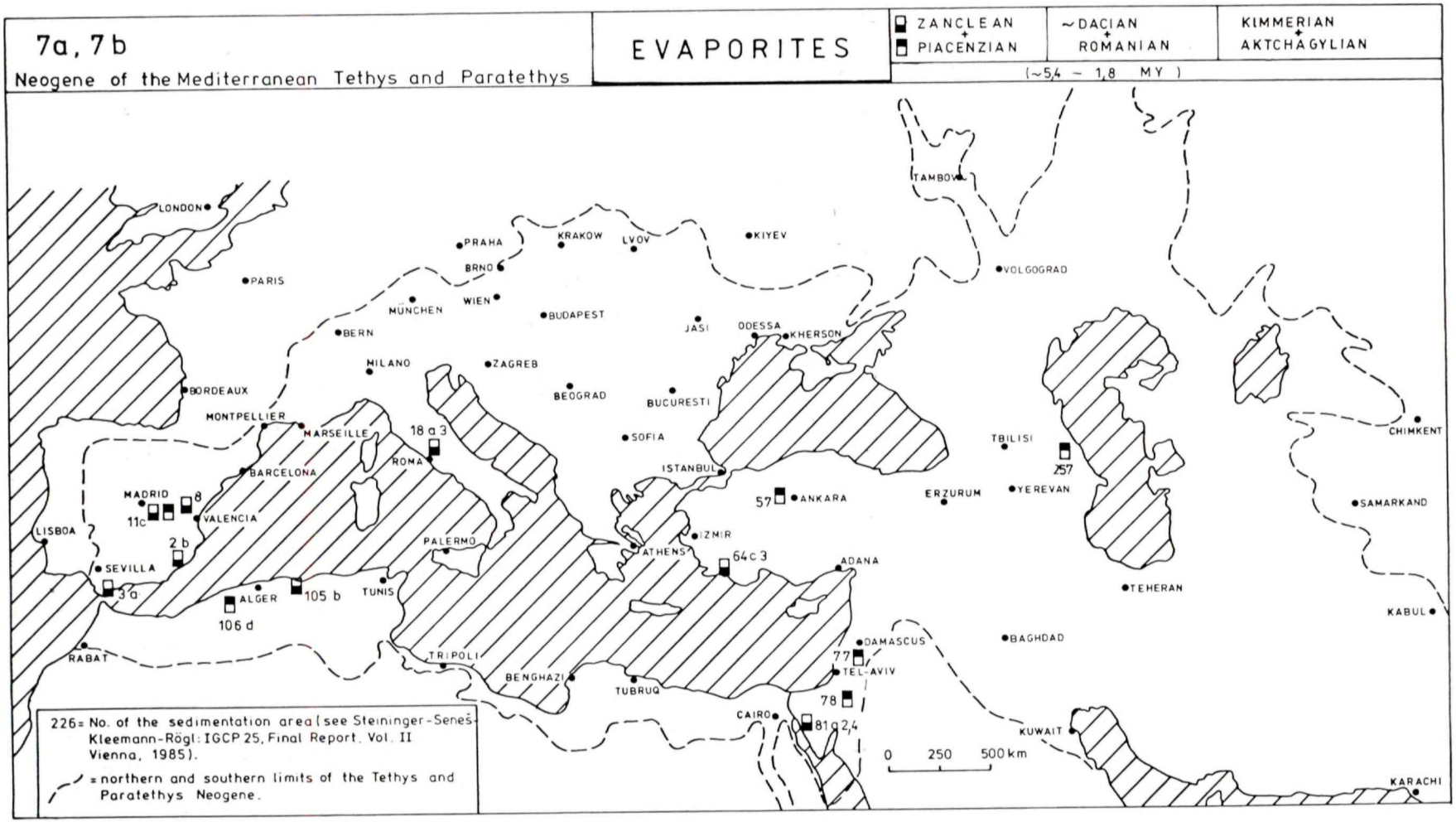
1c — Betic Depr., Iberic-Betic B., E; **2b 1, 2** — Granada B., W., Centr. (low. part of "Tramo superior Miocenico") E; **42a** — SW. Akarnania Marginal B. (uppermost part of the "Rizza" Bds.) GR; **75a** — Tel Aviv — El Arish (lower part of the Mavoiim Fm.") IL, ET; **101b/106a** — Bordure N. des Tessala, DZ; **102f** — S. du Titteri (Draa El Asnam, Sondage GRN-1), (uppermost part of the "Grès de Tiaret") DZ; **104e** — Bassin Littoral E. de l'Oran (lowermost Bds. of the overlaying Messinian cycle) DZ; **106f** — Bordure S. de Dahra (Oued Djelloul, Sondage AZ-6) DZ; **114** — SW. Tunisia, Chott Jerid (Gypsum in Saouaf Fm.) TN;

5e Early — Middle Tortonian

10a 1, 3 — Duero B., W., S. and Centr. Vallaloid, Zamora ("Gypsoferous facies", "Portillo facies") **E; 80b2** — North Red Sea


5a,5b,5c,5d,5e,5f
Neogene of the Mediterranean Tethys and Paratethys
EVAPORITES
TORTONIAN
(11,3 – 6,4 MY)
PANNONIAN
early + middle
PONTIAN (CP)
BESSARABIAN +
CHERSONIAN + MAEOTIAN
early + middle
PONTIAN (EP)
LONDON
PARIS
PRAHA
KRAKOW
LVOV
KIYEV
BRNO
WIEN
MÜNCHEN
BUDAPEST
BERN
JASI
ODESSA
KHERSON
VOLGOGRAD
TAMBOV
MILANO
ZAGREB
BEOGRAD
BUCURESTI
BORDEAUX
MONTPELLIER
MARSEILLE
SOFIA
TBILISI
CHIMKENT
ROMA
BARCELONA
ISTANBUL
ANKARA
ERZURUM
YEREVAN
SAMARKAND
MADRID
VALENCIA
LISBOA
SEVILLA
PALERMO
IZMIR
ATHENS
ADANA
TEHERAN
KABUL
ALGER
TUNIS
TRIPOLI
BENGHAZI
TUBRUQ
RABAT
DAMASCUS
BAGHDAD
TEL-AVIV
CAIRO
KUWAIT
KARACHI
10a 1,3
8
11a,b
1c
2b 1,2
104a
104c
106d
107d
106a
106b
105b
110
111
112
113
114
102f
101b
42a
41
67a
70a
254
151
353
75a
81abc
80b2
80a1,2
80b1
0
250
500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.


6a, 6b, 6c, 6d
Neogene of the Mediterranean Tethys and Paratethys
EVAPORITES
MESSINIAN
(~ 6,4 – 5,4 M Y)
Messinian in general
early
middle
late
LONDON
PARIS
BORDEAUX
BERN
MÜNCHEN
WIEN
PRAHA
BRNO
KRAKOW
LVOV
KIYEV
TAMBOV
VOLGOGRAD
BUDAPEST
JASI
ODESSA
KHERSON
ZAGREB
BEOGRAD
BUCURESTI
MILANO
MONTPELLIER
MARSEILLE
BARCELONA
MADRID
VALENCIA
LISBOA
SEVILLA
ROMA
SOFIA
ISTANBUL
ANKARA
ERZURUM
TBILISI
YEREVAN
CHIMKENT
SAMARKAND
TEHERAN
KABUL
PALERMO
IZMIR
ATHENS
ADANA
ALGER
TUNIS
TRIPOLI
BENGHAZI
TUBRUQ
CAIRO
RABAT
DAMASCUS
BAGHDAD
TEL-AVIV
KUWAIT
KARACHI
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.


7a, 7b
Neogene of the Mediterranean Tethys and Paratethys
EVAPORITES
ZANCLEAN
PIACENZIAN
DACIAN
ROMANIAN
KIMMERIAN
AKTCHAGYLIAN
(~5,4 – 1,8 MY)
LONDON
PARIS
PRAHA
KRAKOW
LVOV
KIYEV
BRNO
MÜNCHEN
WIEN
BUDAPEST
BERN
JASI
ODESSA
KHERSON
MILANO
ZAGREB
BORDEAUX
BEOGRAD
BUCURESTI
MONTPELLIER
MARSEILLE
18 a 3
SOFIA
ROMA
BARCELONA
ISTANBUL
MADRID
8
11c
VALENCIA
57
ANKARA
ERZURUM
YEREVAN
LISBOA
2 b
PALERMO
IZMIR
ATHENS
64c 3
ADANA
SEVILLA
3 a
ALGER
105 b
TUNIS
106 d
TRIPOLI
BENGHAZI
TUBRUQ
CAIRO
DAMASCUS
77
TEL-AVIV
78
81a 2,4
RABAT
TAMBOV
VOLGOGRAD
TBILISI
257
CHIMKENT
SAMARKAND
TEHERAN
KABUL
BAGHDAD
KUWAIT
KARACHI
0 250 500 km
226= No. of the sedimentation area (see Steininger-Seneš-Kleemann-Rögl: IGCP 25, Final Report, Vol. II Vienna, 1985).
= northern and southern limits of the Tethys and Paratethys Neogene.

B. (low.part of the Samh Fm.) ET; **254** — Nachitchevan Depr. SU; **353** — Mesopotamian B. ("Lower Fars Fm.") IRQ;

5f. Middle-Late Tortonian

70a — Hinis B. (upp.part of the Alibonca Fm.) TR; **81a2** — Gulf of Suez B. (midd. and upp.part of the Zeit Fm.) ET; **107d** — Bassin de Constantine, DZ; **112** — Tunisie Orientale — Sahel (Gypsum in Souaf Fm.) TN;

6. Messinian (~6,4—5,4MY)

6a. Messinian in general

8 — Iberic Depr. (Tortajada Fm.) E; **27a-d** — Sicily: Cimmina B., Madonie-Nebrodi Mts., Sicani-Trapanese Mts., Castelvetrano B. ("Gypsum Fm.") I; **41** — Thracian Marginal B., Nestos River Delta ("Evaporitic Fm.") GR; **42a** — SW. Akarnania Marginal B. (Yannates "Fm.") GR; **104d, e** — Bassin Littoraux de Mers El Kebir du Murdjadjo et a l'E. d'Oran, DZ; **107b** — Nelsonbourg, DZ; **127** — Valencia Through (in DSDP Site 122) MED; **128** — Belearic B. (in DSDP Site 372, "Unit 2") MED; **130a** — Tyrrhenian E. (in DSDP Site 132) MED; **139** — Messina Abyssal Plain (in DSDP Site 374) MED; **143** — Cretean B. (in DSDP Site 378, 378A) MED;

6b. Early Messinian

2b 1, 2 — Granada B. W. and Centr. (middle part of the "Tramo superior Miocenico") E; **3b** — Betic Ranges (uppermost part of the "TSU-Ne-4") E; **17d3** — Romagna Apennine ("Evaporite Fm.") I; **28** — Marches-Abruzzes B. (Gessoso Solifera Fm.) I; **46c** — Crete: Iraklion (in Vrysses Gr.) GR; **54** — Izmir-Urla, TR; **75a** — Tel Aviv — El Arish (upp.part of the Mavoiim Fm.) IL, ET; **107d** — Bassin de Constantine, DZ; **110** — Bizerte (Oued del Khedim Fm. — base) TN; **111** — Cap Bon (upper part of the Saouaf Fm.) TN; **113** — Plateau sous-marin de Kerkennah, Golfe de Gabes (? base of the Oued del Khedim Fm.) TN; **138** — Adriatic-Ionian B., MED;

6c. Middle Messinian

5ab — Valencia Platform, North Balearic Through ("Evaporitic Mb.") E;**17a 1, 2** — Piemont B. Centr. and NE. (Gessoso Solifera Fm.) I; **17d2** — Emilia, Western Apennine ("Evaporitic Fm.") **I; 19** — Pontine Depr., **I; 23** — Calabria Crotone B. ("Evaporitic inf. — sup. Fm.") I; **24** — Calabria, Punta Stilo, I; **25** — Sicily: Caltanisetta B. ("Gypsum Fm.") I; **26a** — Sicily: Iblei Mts. ("Gypsum Fm.") I; **33d** — External Ionian Zone (in upper part of the "Rizza Fm.") GR; **37acd** — Corfu: Kefallinia, Zakynthos, GR; **45a** — North Sporades, Skyros, GR; **45b** — Milos (in "transgressive series") GR; **46a** — Crete: Khania (in Vrysses Gr.) GR; **46d** — Crete: Ierapetra (in Vrysses Gr.) GR; **49b** — Cyprus: Dhali Area, S. Mesaoria (middle part of the Kalavasos Fm.) CY; **49c** — Cyprus: Polemi B. (Leytembou Mb.) CY; **82a 4, 6** — Nile Delta B. (Rosetta Anhydrit Fm.) ET; **104f** — Dahra DZ; **107d** — Bassin de Constantine, DZ: **112** — Tunisie Orientale — Sahel (upp. part of the Saouaf Fm.) TN; **113** — Plateau sous-marin de Kerkennah, Golfe de Gabes (? middle part of the Oued del Khedim Fm.) TN; **140** — Syrte Abyssal Plain — Ionian Sea (in DSDP 125) MED; **150a** — Mediterranean Coast, Nahr El-Kabir Depr., Idlib Foredeep NW., SYR;

6d. Late Messinian

8 — Iberic Depr. (in middle part of the Alfambra Fm .) E; **18b** — Volterra B. (overlaying Rosignano Fm.) I; **19** — Pontine Depr., I; **25** — Sicily: Caltanisetta B. (upp.part of the "Gypsum Fm.") I; **26a** — Sicily: Iblei Mts. (upp.part of the "Gypsum Fm.") I; **37acd** — Corfu: Kefallinia, Zakynthos, GR; **46c** — Crete: Iraklion (in upper part of the Vrysses Gr.) GR; **49ab** — Cyprus: Kythera Area, N. Mesaoria, Dhali Area, S. Mesaoria, CY; **63** — Ulukisla B., TR; **68** — Antakya B., TR; **97c** — Boudinar MA; **101b/106abc,efg** — Bordure N. de Tessala, Plateau de St. Louis, Bordure N. de Beni Chougrane, Bas Cheliff, Bordure S. du Dahra, Zone axiale du Bas-Cheliff, DZ; **104f** — Dahra, DZ;

7a. Zanclean = ± Dacian = ± Kimmerian (~ 5,4—3,4 MY)

2b — Betic Ranges (middle part of the "TSU-Ne-5") E; **3a** — Malaga Coastal Area (in Malaga Fm.) E; **8** — Iberic Depr. (upp.part of the "Tortajada Fm.") E; **11c** — Tajo-Guadiana B., Jucar (low-part of the "Yesares Unit") E; **18a 3** — Radicofani B., I; **64c 3** — SW. Anatolia, Zone of Menderes Massif (middle part of the "Karacasu Layers") TR; **81a 2, 4** — Gulf of Suez B., ET; **105b** — Region d'Alger, DZ;

7b. Piacenzian = ± Romanian = ± Aktchagylian (~ 3,4—1,8 MY)

11c — Tajo-Guadiana B., Jucar (upp.part of the "Yesares Unit") E; **57** — Beypazari-Nallihan, TR; **77** — Tiberias B. (Gesher Fm.) IL; **78** — Jordan Rift Valley (Sedom Fm.) IL; **106d** — Bassin du Bas-Cheliff (Zanclean/Piacenzian boundary) DZ; **257** — Kussaro-Divichin Synclinorium, SU.

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Evapority mediteránnej neogénnej oblasti Tetýdy a Paratetýdy; aplikácia výsledkov projektu IGCP č. 25; časť 3

Mapové prílohy záverečnej správy projektu (Steininger et al., 1985) len schematicky znázorňovali výskyt evaporitov v jednotlivých obdobiach neogénu na území medzi dnešným Atlantikom a Indopacifikom. Vzhľadom na paleogeografický význam (predovšetkým paleoklimatický) vyplývajúci z ich vzniku, či už v regionálnom alebo interregionálnom meradle, pokladáme za užitočné sumarizovať ich presnejšiu stratigrafickú a priestorovú príslušnosť.

Predkladáme grafické znázornenie ich rozšírenia už od vrchného oligocénu (obr. 1—7).

Osobitný dôraz kladieme na priestorové rozšírenie evaporitov vo vyššom strednom bádene v oblasti centrálnej Paratetýdy a v messine v oblasti mediteránnej Tetýdy. V týchto dvoch obdobiach boli v oboch oblastiach nesporne najpriaznivejšie paleogeografické a paleoklimatické podmienky interregionálneho, ale aj medzikontinentálneho charakteru na vznik teritoriálne rozsiahlych ložísk.

Uvádzame predovšetkým evapority hyperhalinného morského (lagunárneho) a hyperhalinného jazerného pôvodu. Ide predovšetkým o ložiská NaCl, KCl, KCl + $MgCl_2 + 6H_2O$, $KCl + MgSO_4 + H_2O$, $CaSO_4$, $CaSO_4 + 2H_2O$, $2CaSO_4 + MgSO_4 + K_2SO_4 + 2H_2O$, $MgSO_4 + H_2O$, z ktorých prevláda kamenná soľ, anhydrit a sadrovec.

Z grafických príloh je zrejmé, že vo vyššom strednom bádene sa vhodné podmienky na vznik evaporitov vytvorili v čelnej hlbine karpatského oblúku a miestami aj v severovýchodnej a východnej časti vnútrokarpatskej oblasti. Okrem aridnosti podnebia v tomto období to naznačuje aj regresia paratetýdneho mora smerom k mediteránnej Tetýde a k Indopacifiku a jeho splytčovanie. V dôsledku toho mohli evapority vzniknúť hlavne v predpolí vyzdvihnutých pásmových pohorí, ktoré mali ešte spojenie s rozpadajúcim sa strednobádenským morom, ale boli to už viac-menej izolované rozsiahle lagúny. Bol to prvý náznak odškrtenia Paratetýdy od neogénnej Tetýdy už koncom stredného bádenu (teda asi začiatkom seravalu). Po tomto prvom prejave čiastočnej izolácie bolo však úplné odškrtenie Paratetýdy od Tetýdy prerušené ešte jednou výraznou transgresiou, a to vo vrchnom bádene. Tá zaplavila okrem celého územia centrálnej Paratetýdy pravdepodobne aj značnú časť východnej Paratetýdy, kde sa prejavila v konkskom stupni vyššou salinitou tamojšieho mora. V predchádzajúcom období (Karaganian) vznikli súčasne s naším stredným bádenom aj vo východnej Európe a v juhozápadnej Ázii vo viacerých oblastiach lagunárne prostredia s tvorbou evaporitov.

Enormný výskyt evaporitov v messine je predovšetkým v rozsiahlych oblastiach mediteránnej Tetýdy. Geodynamické a paleogeografické príčiny ich vzniku sú dnes vďaka úspešnému ukončeniu IGCP projektu č. 96 už dostatočne vysvetlené (Cita, 1982).

Pozoruhodná je však koncentrácia výskytu evaporitov v niektorých iných oblastiach širšieho mediterránneho regiónu (Circummediterran Area) aj v iných časových intervaloch neogénu než vo vyššom strednom bádene alebo v messine. V anglickom texte uvedená analýza ich vekového a priestorového rozšírenia môže poskytnúť údaje na ďalšie paleogeografické a geodynamické rekonštrukcie.