The Clean Paper

WHAT THE PAPER SAYS · WHAT IT DOESN'T · WHY IT MATTERS

Fossil record New Mexico seenaa dinosaurs dhumaa caalaatti walxaxaa godha

Qorannoon Science Naashoibito Member New Mexico date haaraa gochuun asteroid impact dura waggoota dhibba-kumaatama muraasa xumuraa keessatti kaa'a. Kun barbaachisaa dha, sababni isaas end-Cretaceous dinosaur evidence gaariin baay'een north irraa dhufa. Southern record haaraan western North America xumura bira regional dinosaur faunas adda adda qabaachuu, community uniform tokko qofa gadi bu'aa hin turre, deeggara. Dinosaurs world guutuu irratti impact hanga dhufu flourishing turan hin mirkaneessu; regional fossil record global story baay'ee smooth gochuu akka danda'u agarsiisa.

Written by Cinzia Vaglio · Cross-checked by Lucio Vaglio and Vera Rubin · Edited by Michele Renda · Figures by Lucio Vaglio and Nova Vela · AI-assisted, human-reviewed

Paper: *Late-surviving New Mexican dinosaurs illuminate high end-Cretaceous diversity and provinciality*, Andrew G. Flynn, Stephen L. Brusatte, Alfio Alessandro Chiarenza, Jorge Garcia-Giron, Adam J. Davis, C. Will Fenley IV, Caitlin E. Leslie, Ross Secord, Sarah Shelley, Anne Weil, Matthew T. Heizler, Thomas E. Williamson, and Daniel J. Peppe, Science 390, 400-404 (2025) · DOI: 10.1126/science.adw3282

Xumura biraa irraa ragaa kibbaa

Seenaa dinosaurs dhumaa yeroo baay'ee northern Great Plains irraa himna: Montana, Dakotas, addunyaa Hell Creek. Galmee sun gaarii waan ta'eef beekamaa ta'e; beekamummaan ammoo yeroo baay'ee guutummaa fakkeessa. Fossils wal-qixa hin faca'an, sababni isaas seenaa uumamaa nuuf file sirriitti kaa'uun hin dirqisiifamne.

Barruu Saayinsii haaraan ragaa kibbaa tokko dabalata. Barreessitoonni **Naashoibito Member** San Juan Basin, Haaraa Mexico keessatti, dhagaa unit fossil qabu, age isaa waggoota dheeraaf irratti falmame, qoran. Fossils kun baay'ee dulloomoo ta'an, moments asteroid rukuttaa dura xumuraa irratti waan xiqqoo jedhu. Latest Cretaceous ta'an ammoo baay'ee barbaachisu.

Deebiin paperichaa isa lammaffaa dha. Geochronology fi magnetostratigraphy haaraa fayyadamuun, ijoo dinosaur-bearing horizons Naashoibito Member **Cretaceous–Paleogene daangaa irraa waggoota naannoo 340,000** keessatti jiru jedhu. Kun dinosaurs Haaraa Mexico xumura bira gahaa dhiheessa, gaaffii durii irratti dubbachuuf: dinosaurs duraanuu hir'ata dheeraa keessa turanii moo ecosystems hedduun rukuttaa yeroo dhufu ammallee regionally diverse turan?

Deebiin of-eeggannoo qabu "dinosaurs hundi baay'ee gaarii turan, achiis boom" miti. Hima kana rhythm gaarii qaba, garuu saayinsii gaarii miti. Deebiin caalaatti dhiphaa fi faayidaa qabu: western North America keessatti galmee kibbaa age isaa sirriitti murtaa'e, late dinosaur faunas ammallee **regionally distinct** akka turan deeggara; community diversity gadi bu'ee bakka hunda irratti yeroo tokkootti badu tokko qofa miti.

Kun gahaa dha. Hat guddaa hin barbaadu.

Bisti/De-Na-Zin Wilderness Haaraa Mexico keessatti, badlands landscape San Juan Basin naannoo bal'aa keessa. Suuraan haala dha, Saayinsii barruu ragaa miti: argument qorannoo dated fossil-bearing strata irratti hunda'a, scenery irratti miti.

Bob Wick / BLM California CC BY 2.0

"Waggoota 340,000 keessatti" jechuun maal jechuu dha?

Asteroid rukuttaa fi Cretaceous–Paleogene daangaa naannoo **66.052 miliyoona waggoota ago** jedhamee date godhama. Gaaffiin dhagaa fossil qaban sarara kana waliin wal-bira qabamee eessa akka jiran dha.

Barreessitoonni dinosaur bones kallattiin date godhanii "rakkoon xumurame" hin jenne. Sandstones Naashoibito section keessaa volcanic mineral grains, keessumaa sanidine, **$^{40}Ar/^{39}Ar$ geochronology** fayyadamuun date godhan; dates kana **magnetostratigraphy** — magnetic reversals Lafa dhagaa keessatti eegamanii hafan — waliin walitti makatan.

Gosa gabaabaa: saamudaa tokko maximum depositional age **66.87 ± 0.04 miliyoona waggoota**, saamudaa dinosaur-bearing biraa **66.38 ± 0.08 miliyoona waggoota** kenna; magnetic akkaataa section gubbaa Cretaceous reversed-polarity interval isa dhumaa keessatti kaa'a. Constraints walitti makaman ijoo dinosaur-bearing horizons daangaa baay'ee dhihoo kaa'u. Kun geological clock dha, stopwatch miti; garuu argument jijjiiruuf gahaa dhihoo dha.

Barreessitoonni maal godhan

Teamichi hojii gosa lama walitti makate; lamaan wal barbaadu. Jalqaba, age Naashoibito Member caalaatti sirreessan. Unit sun dhagaa Campanian durii gubbaa fi dhagaa jalqabaa Paleocene jala jira, garuu sirrii age falmisiisaa ture: interpretations duraanii muraasni 70–69 miliyoona waggoota ago keessa kaa'an, kanneen biroon latest Cretaceous jedhu, himannoowwan muraasni galmee keessaa kutaa tokko Paleocene keessa illee galchan. Barreessitoonni sections safaran, localities dinosaur-bearing saamudaa godhan, detrital sanidine grains $^{40}Ar/^{39}Ar$ malleen'n date godhan, fi section intervals magnetic polarity beekamoo waliin wal qabsiisan.

Lammaffaa, fauna haala keessatti akkam akka ture gaafatan. Terrestrial fi freshwater vertebrate occurrence daataa western North America Campanian, Maastrichtian fi jalqabaa Paleocene irraa walitti qaban; ecological fi biogeographic malleen fayyadamuun faunas regional moo uniform ta'uu qoran. Jechi ijoo **provinciality** dha: naannoowwan adda adda communities adda adda qabaachuu, bakka hunda animals sanuma qofa miti.

Kun barbaachisaa dha sababni isaas gosa seenaa late dinosaur tokko western North America Maastrichtian keessatti caalaatti homogeneous ta'e, regional garaagarummaa hir'atan fi fauna cosmopolitan ta'e jedhu. Sirna uniform, diversity gadi-aanaa tokko asteroid dura vulnerable fakkaachuu danda'a. Sirna regional caasaa qabu seenicha adda godha.

Maal argatan

Dating ijoo dha. saamudawwan dinosaur-bearing Naashoibito lama constraints late Maastrichtian qabu. Sandstone saamudaa H08-Sand-08 maximum depositional age **66.87 ± 0.04 miliyoona waggoota** kenne. saamudaa "34-Bone Site," partial lambeosaurine hadrosaur skeleton qabu, maximum depositional age **66.38 ± 0.08 miliyoona waggoota** kenne. Magnetic polarity galmee waliin, barreessitoonni ijoo Naashoibito dinosaur-bearing horizons K-Pg daangaa irraa naannoo **340,000 waggoota** keessatti kaa'u.

Kun San Juan Basin galmee Hell Creek faunas north keessatti beekamoo waliin broadly contemporaneous godha. Naashoibito dinosaurs fi earliest Paleocene Nacimiento fauna gidduutti naannoo **700,000 waggoota** adda baasa; kun barbaachisaa dha, sababni isaas non-avian dinosaurs extinction daangaa gama dogoggoraa irratti kaa'uun hin barbaachisu. Inni messy qofa miti; dogoggora dha.

Ecological bu'aa kutaa biraa dha. Latest Cretaceous intervals isaan qoratan keessatti barreessitoonni western North America keessatti **bioprovinces lama** ragaa argatan. Dinosaurs qofa analyze yeroo godhanis latest Cretaceous yeroo intervals qorannoo keessaa hunda irratti bioprovinces lamaatti qoodaman. barruun regional garaagarummaa kun asteroid dura community uniform tokko keessatti hin badne jedhu.

Driver sarara north-south qofa miti. Xiinxalawwan isaanii **ho'a** faaktara ijoo bioprovinces Cretaceous bocu akka ta'e, geography gahee lammaffaa qabaachuu agarsiisu. Southern naannoowwan ho'aan animals muraasa, akka sauropods, deeggaruu danda'an; northern naannoowwan qabbanaa'aan

hadrosaurines akka caalaatti deeggare. Qabxii isaa province hundi isa biraa caalaa “healthy” ture jechuu miti. Late Cretaceous kaartaa ammallee caasaa qaba ture jechuu dha.

Kun maal *hin* mirkaneessu

- Dinosaurs Lafa hunda irratti asteroid hanga dhufu flourishing turan jechuu **hin mirkaneessu**. Barreessitoonni picture kun ammallee baay’inaan North America irratti hunda’a jedhu.
- Gareewwan, naannoowwan yookaan xiinxalawwan muraasa keessatti hir’ata ragaa jiru hin balleessu. Seenaa continent-wide baay’ee smooth ta’e irratti morma, stress versions hunda irratti miti.
- Asteroid muhiim miti jechuu hin agarsiisu. Rukuttaa daangaa irratti event ijoo ta’ee hafa; barruun ecosystems akkamii irratti akka bu’e gaafata.
- Haaraa Mexico world guutuu irratti perfect window hin godhu. Galmee northern sites’n dominated ta’e keessatti southern daataa qabxii missing tokko dabala.
- “Flourishing until rukuttaa” mata-duree nageenya qabu hin godhu. Kun himannaa bal’aa dha, bu’aa qulqulluu miti.

Ragaan hammam cimaa dha?

Age Naashoibito dinosaur-bearing horizons irratti main-text ragaa hiika qabu ta’uu ga’a. Barreessitoonni detrital sanidine grains radioisotopic dates fi magnetostratigraphy walitti maku; key dates latest Cretaceous hiika waliin wal-simu. barruun controversy duraanii fossils baay’ee older, latest Cretaceous yookaan Paleocene ta’uu irratti kallattiin deebii kenna.

Caveat teknikaa tokko jira. Detailed geochronology, magnetic hiika fi daataa tables Saayinsii supplementary maateriyaalota keessa jiru. Ijoo barruu himannoowwan fi lakkoofsota barbaachisaa kenna; garuu maxxansa pass dhumaa keessatti supplement sakatta’uun sirrii dha, methodological bal’ina ibsaa hunda akka xumurameetti fudhachuu dura.

Ecological himannaa bal’aa irratti ragaa suggestive fi faayidaa qabu dha, garuu model-dependent caalaatti. Barreessitoonni occurrence kuusaa daataa, clustering fi resampling fayyadamuun bioprovinces irraa hubatu. Meeshaa gaarii dha, garuu bu’aa fossil saamudaa fudhachuu, taxonomic assignments, yeroo binning fi absences akkamitti handle godhaman irratti hirkata. Fossil galmeewwan daataa “ilkaan dhabame” qabu.

Kanaaf dubbisuu nageenya qabu qoodama: Haaraa Mexico galmee late Cretaceous southern galmee dhugaa fi barbaachisaa dha; western North America xumura bira regional faunal caasaa qaba ture jedhu xiinxalawwan barreessitoonni’n gaarii deeggara; kana irraa waliigalaa dinosaur fayyaa irratti jump gochuun irraa of qusachuu qabna.

Maaliif barbaachisaa dha

Marii dinosaur hir'ata durii dinosaurs qofa irratti miti. Fossil galmee tokko seenaa hammam ulfaataa baachuu danda'a jedhu irratti dha.

Isa gaarii end-Cretaceous galmee northern Great Plains irraa yoo dhufe, galmee sana ardii bakka bu'u gochuun, achiis ardii world bakka bu'u gochuun nama hawwata. Efficient dha. Garuu akkasuma regional akkaataa "ticket malee elevator" yaabbatee waliigalaa seenaa ta'a.

Bu'aan Haaraa Mexico seenaa kana caalaatti uneven godha. Inni "gara kibbaa ilaali" jedha. Dinosaur-bearing unit daangaa dhihoo jira. Faunas northern ones qofa copy hin taane jira. Ho'a fi regional ecology late in the game illee barbaachisaa turan jechuun ragaa jira.

Kun asteroid catastrophe xiqqeessu miti. Tarii tragedy caalaatti ifa godha. Rukuttaa sun simplified ecosystem tokko qofa irratti hin buune; regional worlds qindaa'ina isaanii qaban irratti bu'e.

Barruu keessatti lesson callisaa tokko illee jira: **dating gaariin narrative jijjiira**. Fossil assemblage age isaa hin beekamne bones waliin rumor ta'uu danda'a. Clock irratti bakka sirrii kaa'i; fossils sanuma ragaa ta'u.

Cuunfaa gabaabaa

Qorannoon Saayinsii Naashoibito Member Haaraa Mexico, dinosaur-bearing unit age isaa yeroo dheeraaf falmisiisaa ture, irra deebi'ee qore. Detrital sanidine $^{40}Ar/^{39}Ar$ dating fi magnetostratigraphy fayyadamuun, barreessitoonni guddaa dinosaur-bearing horizons Cretaceous–Paleogene daangaa irraa naannoo 340,000 waggoota keessatti kaa'u; kanaan North America keessatti non-avian dinosaurs dhumaa keessaa ta'u fi Hell Creek faunas north waliin broadly contemporaneous ta'u. Achiis ecological fi biogeographic xiinxalawwan western North American vertebrate occurrences fayyadamuun late Cretaceous faunas regional caasaa eegan jedhu: dinosaurs bioprovinces lamaatti qoodaman, fi ho'a garaagarummaa kanaaf driver ijoo fakkaata. Bu'aan low-diversity, continent-wide fauna tokko asteroid dura uniform ta'ee fade godhe jedhu irratti morma. Waliigalaa dinosaur fayyaa hin mirkaneessu, hir'ata debate hunda hin furu, dinosaurs hundi xumura hanga thriving turan hin jedhu. Inni southern galmee caalaatti sirriitti date godhame dhumaa North American seenaa regional, structured fi xiqqaa smooth akka ta'e agarsiisa.

Sakatta'a ifaa

barruun maal agarsiisa: Naashoibito Member dinosaur-bearing horizons Haaraa Mexico latest Cretaceous dha, carraan isaa guddaa K-Pg daangaa irraa naannoo 340,000 waggoota keessatti; western North American vertebrate galmee xumura bira regional bioprovinces itti fufan deeggaru.

Wanti amansiisaa garuu hin mirkanoofne: Dinosaur ecosystems hedduun asteroid dura ammallee

jabaataa turan; ho'a northern fi southern faunal worlds adda eeguuf gargaare; yaada hir'ata continent-wide salphaan baay'ee smooth dha.

Wanti hin agarsiifne: Dinosaurs bakka hunda thriving turan; gareewwan yookaan naannoowwan tokko illee hir'ata hin qabne; asteroid extinction trigger ijoo hin taane; Haaraa Mexico qofti waliigalaa end-Cretaceous seenaa irra deebi'ee barreessa.

Daangaa ijoo: Regional fossil galmee; provinciality xiinxala model-dependent; fossil saamudaa fudhachuu bias; bal'aa geochronology fi occurrence malleen Saayinsii supplementary maateriyaalota waliin dhumaa sakatta'uu barbaadu.

Dubbisaan waliigalaa hammam amanuu qaba? Haaraa Mexico southern late Cretaceous dinosaur galmee barbaachisaa kennu irratti amantaa guddaa. Western North America xumura bira regional faunal caasaa eegu irratti gaarii. "Dinosaurs bakka hunda asteroid hanga dhufu gaarii turan" jechuun compress gochuu irratti amantaa gadi-aanaa. Bu'aan dhugaa caalaatti gaarii: chapter dhumaa continent-wide seenaa diriiraa tokko miti.

Maddoota

Flynn et al., Late-surviving New Mexican dinosaurs illuminate high end-Cretaceous diversity and provinciality, Science 390, 400-404 (2025)
https://doi.org/10.1126/science.adw3282