



The CLEAN PAPER

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

Fossil record New Mexico kan ní jé kí last chapter dinosaurs di complicated síi

Science study kan redates Naashoibito Member ní New Mexico sí final few hundred thousand years before asteroid impact. New southern record suggests western North America sì ní regionally distinct dinosaur faunas near end, rather than one uniform fading community. Kò prove pé every dinosaur ecosystem worldwide flourishing until impact; ó show why regional fossil record can make global story too smooth.

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Elérí kan láti guúsù, nítòsí òpin

A sàbà ní sọ itan àwọn dinosaurs ikehin nípasẹ northern Great Plains: Montana, Dakotas, Hell Creek world. Record yẹn dára tó bẹẹ tí ó fi di ohun tí gbogbo wa mò, familiarity sì maa ní ẹ bí completeness. Fossils kò pin ka gbogbo ibi ní iwọn kan, nítorí history kò fi ara rẹ pamọ sí files fún wa.

Science iwé iwádíí tuntun kan fi southern witness kún un. òhòkòwé iwádíí Naashoibito Member nínú San Juan Basin ti New Mexico, fossil-bearing àpáta unit tí age rẹ ti jẹ ariyanjiyan fún decades. Tí fossils wònyí bá older, wón kò ní sọ púpò nípa final moments sáájú asteroid impact. Tí wón bá late Cretaceous gan-an, wón maa matter púpò.

Answer iwé iwádíí jẹ option kejì. Pélú geochronology tuntun àti magnetostratigraphy, ẹgbé nàà argue pé pàtàkì dinosaur-bearing horizons nínú Naashoibito Member wà nínú nípa **340,000 years** of Cretaceous-Paleogene àlà. Èyí gbe New Mexico dinosaurs sún mó end tó bẹẹ tí wón lè contribute sí old ibèèrè: ẹ dinosaurs ti ní decline fún igba pípé, tàbí many ecosystems sì regionally diverse nígbà impact dé?

Careful answer kì í ẹ “gbogbo dinosaurs ní ẹ dáadáa, lẹyìn nàà boom.” Gbolohun yẹn ní rhythm, sùgbón manners rẹ buru. Better answer dín síi: ní western North America, southern àkòsílẹ tó well-dated ẹ àtílẹyìn fún picture of late dinosaur faunas tí sì regionally distinct, kì í ẹ single low-diversity community tó fade everywhere at once.

Èyí tó. Kò nílò hat tó louder.



Bisti/De-Na-Zin Wilderness ní New Mexico, badlands landscape nínú broader San Juan Basin region. Image jẹ context, kì í ẹ ẹrí láti Science iwé iwádíí: argument iwádíí gbára lẹ dated fossil-bearing strata, kì í ẹ scenery.

Kí ni “within 340,000 years” túmò sí níhìn-ín?

Asteroid impact àti Cretaceous-Paleogene ààlà dated sí nípa **66.052 million years ago**. Ìbèèrè ni ibi tí fossil-bearing àpáta wà relative sí line yèn.

ònkòwé kò date dinosaur bones taara kí wòn sì sọ pé matter closed. Wòn date volcanic mineral grains, pàápàá sanidine, láti sandstones nínú Naashoibito section pèlú ⁴⁰Ar/³⁹Ar geochronology, wòn sì combine dates pèlú **magnetostratigraphy**: àkọsílẹ̀ of Earth’s magnetic reversals preserved nínú àpáta.

Short èdà: àpẹẹẹ kan gives maximum depositional age **66.87 ± 0.04 million years**, òmíràn dinosaur-bearing àpẹẹẹ gives **66.38 ± 0.08 million years**, magnetic àpẹẹẹ sì place upper section nínú final reversed-polarity interval tí Cretaceous. Together, constraints wònyí put pàtàkì dinosaur-bearing horizons near ààlà. Geological clock ni, kì í ẹ̀ stopwatch, sùgbọ̀n close enough láti change argument.

Ohun tí àwọn olùkòwé ẹ̀

ẹgbẹ̀ nàà combine kinds of ọ̀ṣẹ̀ méjì tí wòn nílò ara wòn. Àkọ́kọ́, wòn tighten age tí Naashoibito Member. Unit nàà wà above older Campanian àpáta àti below early Paleocene àpáta, sùgbọ̀n exact age contested: earlier interpretations kan gbe e sí around 70-69 million years ago, others argue latest Cretaceous age, claims díẹ̀ pàápàá push parts of àkọsílẹ̀ wọ̀ Paleocene. ònkòwé measure sections, àpẹẹẹ dinosaur-bearing localities, date detrital sanidine grains pèlú ⁴⁰Ar/³⁹Ar ọ̀nà, wòn sì tie section sí known magnetic polarity intervals.

Èkejì, wòn bèèrè bí fauna ẹ̀ rí in context. Wòn assemble terrestrial àti freshwater vertebrate occurrence dátà láti western North America kọ́já Campanian, Maastrichtian àti early Paleocene, lẹ́yìn nàà lo ecological àti biogeographic ọ̀nà láti ọ̀dánwò whether faunas regional tàbí uniform. Keyword ni **provinciality**: whether yàtò regions ní distinct communities, dípò animals kan nàà everywhere.

Èyí ẹ̀ pàtàkì nítorí èdà kan tí late dinosaur history sọ pé western North America di homogeneous síi nínú Maastrichtian, pèlú fewer regional differences àti sí i cosmopolitan fauna. More uniform, lower-diversity ètò lè rọ̀rùn láti imagine as vulnerable ẹ́ájú asteroid. Regionally structured ètò sọ ọ̀tàn mǐràn.

Ohun tí wòn rí

Dating ni hinge. Dinosaur-bearing Naashoibito àpẹẹẹ méjì ní late Maastrichtian constraints. Sandstone àpẹẹẹ H08-Sand-08 yielded maximum depositional age **66.87 ± 0.04 million years**. Sample láti “34-Bone Site,” pèlú partial lambeosaurine hadrosaur skeleton, yielded maximum depositional age **66.38 ± 0.08 million years**. Combined pèlú magnetic polarity àkọsílẹ̀, ònkòwé place major Naashoibito dinosaur-bearing horizons nínú nípa **340,000 years** of K-Pg ààlà.

Èyí mú San Juan Basin àkọsílẹ̀ broadly contemporaneous pèlú better-known Hell Creek faunas farther north. Ó tún separate Naashoibito dinosaurs láti earliest Paleocene Nacimiento fauna ní nípa **700,000 years**, tó ẹ̀ pàtàkì nítorí kò sí ẹ̀ni tó fẹ̀ accidentally put non-avian dinosaurs on wrong side of extinction ààlà. Èyí yóò jẹ̀ untidy —

àti wrong.

Ecological èsì ni other half. Kojá latest Cretaceous intervals tí wọn analyze, òhàkòwé rí ẹ̀rí fún **bioprovinces méjì** nínú western North America. Dinosaurs, analyzed on their own, separate sí bioprovinces méjì kojá gbogbo latest Cretaceous àkókò intervals nínú ìwádíí. ìwé ìwádíí argue pé regional differences wònyí kò simply collapse sí single uniform fauna **ṣáájú** impact.

Driver kì í ẹ̀ north-south line nìkan. Analyses wọn kókó sí **temperature** gégé bí pàtàkì factor shaping bioprovinces nínú Cretaceous, geography secondary. Warmer southern regions lè favor animals kan, bí sauropods; cooler northern regions favor others, bí hadrosaurines. Point kì í ẹ̀ pé province kọọkan healthier ju omi. Ó jẹ pé late Cretaceous map ẹ̀ ní ìṣètò.

Ohun tí ẹ̀yí kò fi ẹ̀rí múlẹ̀

- Kò fi ẹ̀rí múlẹ̀ pé dinosaurs everywhere on Earth thriving títi asteroid hit. òhàkòwé explicit pé picture ẹ̀ largely North American.
- Kò erase ẹ̀rí fún decline nínú ẹ̀gbé, regions tàbí analyses kan. Ó push against overly smooth continent-wide ìtàn, kì í ẹ̀ every ẹ̀é ẹ̀ stress-before-extinction scenario.
- Kò fi hàn asteroid unimportant. Impact remains pàtàkì ìṣẹ̀lẹ̀ at ààlà; ìwé ìwádíí asks what kind of ecosystems were hit.
- Kò turn New Mexico sí perfect window lóri whole pílánẹ̀tì. Ó add southern dátà kókó tí missing nínú àkọ̀sílẹ̀ dominated by northern sites.
- Kò make “flourishing until impact” láìléwu àkólé. Ẹ̀yí jẹ́ broadest claim, kì í ẹ̀ cleanest èsì.

Báwo ni ẹ̀rí ẹ̀ lágbara tó?

Fún age ti Naashoibito dinosaur-bearing horizons, main-text ẹ̀rí lágbara enough to matter. òhàkòwé combine radioisotopic dates láti detrital sanidine grains pẹ̀lú magnetostratigraphy, key dates sì line up pẹ̀lú latest Cretaceous interpretation. ìwé ìwádíí tún address older controversy taara.

Technical caveat ẹ̀ wà. Detailed geochronology, magnetic interpretation àti dátà tables wà nínú Science supplementary ohun èlò. Main ìwé ìwádíí gives necessary claims/numbers, ẹ̀gbọ̀n final publication pass yẹ kí check supplement **ṣáájú** treating every methodological detail closed.

Fún broader ecological claim, ẹ̀rí suggestive àti useful, ẹ̀gbọ̀n sí i model-dependent. òhàkòwé lo occurrence datasets, clustering àti resampling láti infer bioprovinces. Right irinṣẹ̀ ni, ẹ̀gbọ̀n èsì depend lóri fossil sampling, taxonomic assignments, àkókò binning àti how absences handled. Fossil àkọ̀sílẹ̀ jẹ́ dátà pẹ̀lú missing teeth.

Safest reading split: New Mexico àkọ̀sílẹ̀ jẹ́ gidi, important late Cretaceous southern àkọ̀sílẹ̀; conclusion pé western North America retained regional faunal ìṣètò near end well supported by analyses; jump sí global dinosaur health yẹ ká resist.

Kí nìdí tí ó fi ẹ̀ pàtàkì?

Old debate lórí dinosaur decline kì í ẹ̀ nípa dinosaurs nìkan. Ó jẹ́ nípa iye weight tí fossil àkọ̀sílẹ̀ kan lè carry.

Tí best end-Cretaceous àkọ̀sílẹ̀ wá láti northern Great Plains, rọ̀rùn láti jẹ́ kí àkọ̀sílẹ̀ yẹn represent continent, lẹ́yìn continent represent world. Efficient ni. Ó tún jẹ́ bí regional àpẹ̀rẹ́ ẹ̀ di global ìtàn láì ní ticket.

New Mexico èsì mú ìtàn náà less smooth. Ó sọ: wo south. Dinosaur-bearing unit kan wà close to ààlà. Faunas wà tí kò duplicate northern ones. ẹ̀rí wà pé temperature àti regional ecology ẹ̀ matter late in game.

Èyí kò make asteroid less catastrophic. Bí ohunkóhun, ó sharpen catastrophe. Impact kò dé ní end of single simplified ecosystem. Ó lu set of regional worlds tí ẹ̀ ní own arrangements.

Quiet lesson mǐràn: good dating changes narrative. Fossil assemblage láísí secure age lè di rumor pẹ̀lú bones. Fi í sí right part of clock, fossils kan náà di ẹ̀rí.

Àkótán kedere

Science ìwádíí kan re-examine Naashoibito Member ní New Mexico, dinosaur-bearing unit tí age rẹ̀ ti debated. Pẹ̀lú detrital sanidine $^{40}\text{Ar}/^{39}\text{Ar}$ dating àti magnetostratigraphy, òhńkọ̀wé constrain major dinosaur-bearing horizons sí nínú nípa 340,000 years of Cretaceous-Paleogene ààlà, making them among last known non-avian dinosaurs in North America àti broadly contemporaneous pẹ̀lú Hell Creek faunas. Ecological/biogeographic analyses tọ̀ka sí late Cretaceous faunas retained regional ìṣètò: dinosaurs separate sí bioprovinces méjì, temperature likely major driver. èsì push back against ọ̀kan low-diversity continent-wide fauna fading uniformly ẹ̀áájú impact. Kò fi ẹ̀rí múlẹ̀ global dinosaur health, solve every decline debate, tàbí fi hàn gbogbo dinosaurs flourishing until end. Ó fi hàn pé better-dated southern àkọ̀sílẹ̀ makes final North American ìtàn sí i regional, structured, less smooth.

Àyèwò láísí àṣejù

Ohun tí ìwé ìwádíí fi hàn: Naashoibito dinosaur-bearing horizons latest Cretaceous, probably nínú nípa 340,000 years of K-Pg ààlà; western North American vertebrate àkọ̀sílẹ̀ ẹ̀ àtílẹ́yìn fún persistent regional bioprovinces near end.

Ohun tó ẹ́é gbà ẹ̀gbon unproven: Many dinosaur ecosystems ẹ̀ robust just ẹ̀áájú impact; temperature helped maintain distinct northern/southern faunal worlds; older simple continent-wide decline too smooth.

Ohun tí kò fi hàn: Dinosaurs everywhere thriving; no ẹ̀gbẹ́/regions declining; asteroid not pàtàkì trigger; New Mexico alone rewrites global end-Cretaceous.

Main limitations: Regional fossil àkọ̀sílẹ̀; model-dependent provinciality ìtupalẹ̀; sampling biases; detailed ọ̀nà need supplement check.

Ìgbẹ̀kẹ̀lẹ̀ wo ni olùkà gbogboogbo yẹ́ kí ó ní? Gíga pé New Mexico now provides important late Cretaceous

southern dinosaur àkọsílẹ̀. Good pé western North America retained regional faunal ìṣètò near end. Low pé a lè compress sí “dinosaurs were fine everywhere until asteroid.” Real èsì: last chapter wasn’t ọ̀kan flat continent-wide ìtàn.

Àwọn orísun

Flynn et al., Late-surviving New Mexican dinosaurs illuminate high end-Cretaceous diversity and provinciality, *Science* 390, 400-404 (2025)

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